TECHNICAL REPORT
NATICK/TR-77/031

THE PSYCHOMOTOR PERFORMANCE OF WOMEN IN COLD WEATHER CLOTHING

October 1977

UNITED STATES ARMY
NATICK RESEARCH and DEVELOPMENT COMMAND
NATICK, MASSACHUSETTS 01760

Clothing, Equipment & Materials Engineering Laboratory

CEMEL-181

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NATICK/TR–77/031	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* THE PSYCHOMOTOR PERFORMANCE OF WOMEN IN COLD WEATHER CLOTHING		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER CEMEL–181
7. AUTHOR(s) Carolyn K. Bensel, Laura P. Bryan, and Sirvart A. Mellian		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Clothing, Equipment and Materials Engineering Lab US Army Natick Research & Development Command Natick, MA 01760		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 6.2, 1L762716AH70–02 6.3, 1L762723AH98AJ
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Natick Research & Development Command ATTN: DRXNM–VCC Natick, MA 01760		12. REPORT DATE October 1977 13. NUMBER OF PAGES 102
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

PSYCHOMOTOR PERFORMANCE	CLOTHING	BODY MEASUREMENTS
PSYCHOMOTOR TESTS	COLD WEATHER	BODY SIZE
FEMALES	WOMEN	SIZES
HUMANS	PSYCHOMOTOR FUNCTION	(DIMENSIONS)
PROTECTIVE CLOTHING	HUMAN FACTORS ENGINEERING	

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This study was conducted to determine the differential effects on women's psychomotor performance of wearing cold weather clothing designed for them vs. cold weather clothing designed for men. Twenty women performed a battery of tasks under each of 10 clothing conditions. The tasks were divided into the following categories: (1) body flexibility, (2) rate of movement, (3) psychomotor coordination, and (4) manual dexterity. The results indicate that certain features of women's cold weather clothing, particularly fit, contribute to higher performance levels than those attained in men's clothes. In addition, the women's items were rated more favorably by

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20. ABSTRACT (cont'd)

the users than were the men's. Psychomotor performance level and user acceptance also decreased as the number of clothing layers worn was increased, but the layers were not equally deleterious in their effects on performance nor were all aspects of performance equally impaired by wearing a certain combination of layers.

PREFACE

The study reported here was conducted by members of the Human Factors and the Clothing Groups, Clothing, Equipment, and Materials Engineering Laboratory. This work was carried out as part of NARADCOM Project No. 1L762716AH70–02, Army Human Factors Engineering – Man/Environment Compatibility Research, and NARADCOM Project No. 1L762723AH98AJ, Design Study of Women's Field Uniform.

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INTRODUCTION

For cold weather operations in the field, the Army has torso clothing designed for men that consists of up to five layers of jackets, trousers, and liners, all of which can be worn over long underwear. However, only four cold weather clothing items designed specifically for women are available -- one layer of trousers and three layers of upper torso garments. Since this clothing must be augmented by men's items for increased protection, a question arises as to the efficacy of retaining any of the women's items. Before a decision is made in this matter, information should be acquired regarding the adequacy of the fit and sizing of the men's clothes on women. An additional consideration is the differential effect that men's and women's clothing may have on simple body movements. The investigation reported here involved the evaluation of the Army's cold weather clothing with regard to such parameters of psychomotor performance.

Independent Variables

The principal purpose of the present study was to determine the effects of wearing the men's ensemble which was comprised of men's items vs. the effects of wearing the women's ensemble which included the women's items augmented by the men's. Both ensembles consisted of the following layers of clothing: (1) wool shirt and trousers, (2) field coat and trousers, (3) liners for the field coat and trousers, (4) parka and arctic trousers, (5) liners for the parka and arctic trousers.

The items which were designed for women differ along several dimensions from comparable items designed for men, including style, material, and garment proportions. Only torso clothing was used in the present study; the handwear, headwear, and footwear appropriate in a low temperature environment were excluded. Since each test participant performed while wearing one to five layers of men's clothes and while wearing one to five layers of women's items augmented by the men's, the effects of adding layers of clothing to the body could also be evaluated.

Dependent Variables

The dependent variables on which the effects of clothing layers and type were determined were divided into five categories: (1) body flexibility, (2) rate of movement, (3) psychomotor coordination, (4) manual dexterity, and (5) effort exerted for task performance. These measures were part of a larger list proposed by Siegel, Bulinkis, Hatton, and Crain[1] to be used in evaluations of pressure suits and other flight apparel. Tests

[1]Siegel, A. I., Bulinkis, J., Hatton, R., & Crain, K. *A technique for the evaluation of operator performance in pressure suits and other flight apparel* (Tech. Rep. NAMC-ACEL-435). Philadelphia: Naval Air Material Center, 1960.

in all five categories were previously employed by Lockhart and Bensel[2] in a study of the effects of men's cold weather clothing on the psychomotor performance of men.

The **flexibility tasks** evolved principally from an investigation by Saul and Jaffe.[3] The purpose of their study was to develop and analyze quantitative techniques for measuring movement interference due to clothing and equipment. The tasks were used to measure the limits of movement of various parts of the body, including the arm and shoulder, trunk and waist, and leg and hip. They also involved movement of segments in the frontal, the sagittal, and the transverse planes of the body.[4] The flexibility tasks in the present experiment were: (1) Standing Trunk Flexion, (2) Sitting Trunk Flexion, (3) Upper Arm Abduction, (4) Forward Upper Arm Extension, (5) Backward Upper Arm Extension, (6) Upper Leg Abduction, (7) Forward Upper Leg Extension, and (8) Backward Upper Leg Extension. The first two of the tasks involved bending of the upper trunk at the waist in the body's sagittal plane. Upper Arm and Upper Leg Abduction required movement in the frontal plane, while Forward and Backward Upper Arm and Upper Leg Extension were movements in the body's sagittal plane.

Lockhart and Bensel (see reference 2) had men perform these tasks while wearing from one through five layers of men's cold weather clothing over winter underwear. The clothing conditions were: (1) wool shirt and trousers, (2) plus field coat and trousers, (3) plus nylon polyester liners (Std. A liners) in the field layer, (4) plus parka and arctic trousers, (5) plus nylon polyester liners (Std. A liners) in the arctic layer. All flexibility tasks were significantly affected by clothing layers with the exception of Upper Leg Backward Extension. In general, performance levels decreased as the number of clothing layers increased. However, the decreases were not strictly linear; the deleterious impact of some layers on performance was greater than others. For example, on both Standing and Sitting Trunk Flexion, scores did not decrease significantly until liners were used in the field layer, and there were no further effects as additional layers, which represented more than a doubling of the bulk in the waist area, were introduced. On the other

[2] Lockhart, J. M. & Bensel, C. K. *The effects of layers of cold weather clothing and type of liner on the psychomotor performance of men* (Tech. Rep. NATICK/TR–77/01B). Natick, MA: US Army Natick Research and Development Command, June 1977.

[3] Saul, E. V. & Jaffe, J. *The effects of clothing on gross motor performance* (Tech. Rep. EP–12). Natick, MA: US Army Quartermaster Research and Development Center, June 1955.

[4] Roebuck, J. A. A system of notation and measurement for space suit mobility evaluation. *Human Factors*, 1968, *10*, 79–94.

hand, Upper Arm Abduction scores decreased initially when the field layer was worn and again when the arctic layer was added, but there was no effect attributable to the addition of Std. A liners to either of these layers. For the remaining flexibility tasks, scores achieved for one vs. five clothing layers were significantly different from each other, but did not differ from the intervening layers.

In addition to the eight flexibility tasks included in the performance battery for the present study, two rate of movement tasks, the Front and the Side Horizontal Striking Tasks, were used. These were chosen primarily to measure the speed with which subjects could accomplish a given movement or series of movements. Although neither of these tasks was significantly affected by clothing layers in the Lockhart and Bensel study, performance levels on the Front Striking Test tended to be higher when the wool shirt and trousers were worn alone or in combination with the field layer than they were under the remaining conditions.

The psychomotor tasks used in the present study, Railwalking and Pursuit Rotor, have been included in other performance batteries. Kiess and Lockhart[5] used the former in an experiment on the effects of adding one, two, or four layers of Army cold weather clothing to the standard fatigues. Railwalking performance was greatly impaired by the addition of the field coat and trousers with mohair frieze liners (Std. B liners) and decreased further when the parka and arctic trousers with Std. B liners were also used. Lockhart and Bensel also used Railwalking. However, the addition of clothing layers did not impair performance in their study.

The other psychomotor coordination task included in the present performance battery, the Pursuit Rotor, required that the subject use a stylus to track a target which moved in a circle. The stylus was grasped in the hand and tracking was effected by movement of the arm and shoulder. Kiess and Lockhart (see reference 5) used this task in their study of arctic clothing layers and found that time on target decreased when the field coat and trousers with Std. B liners were worn over the standard fatigues. Performance levels decreased further when the parka and arctic trousers with Std. B liners were also used. Lockhart and Bensel also found that time on target decreased as the number of layers increased, with the exception of the field layer with Std. A liner condition, which yielded the lowest score.

[5] Kiess, H. O. & Lockhart, J. M. *Levels of clothing and components of psychomotor performance*. Unpublished manuscript, US Army Natick Laboratories, 1967.

The fourth category of tasks used in the present study was **manual dexterity**. This was represented by the Purdue Pegboard Assembly Test, which involved simultaneous movement of both hands, and the O'Connor Finger Dexterity Test, which was done with one hand. Therefore, possible differential effects of the present clothing conditions on a one– vs. a two-handed task could be assessed. Kiess and Lockhart (see reference 5) obtained a slight performance decrement on the Purdue Pegboard Test when the complete cold-dry uniform was worn. In the more recent Lockhart and Bensel study (see reference 2), these manual tasks were not affected by the clothing worn.

In the present study, **heart rate** was employed as a measure of the effort exerted under the various clothing conditions. It was recorded at selected intervals during the performance of the task battery in order to determine whether higher rates would be associated with some conditions than with others. In the Lockhart and Bensel study, there was a significant difference between the resting heart rate evidenced prior to performance of the battery and the higher rate achieved after the exercises of the battery had been completed. There was also a slight, but not significant, tendency for the second heart rate reading to increase somewhat as the number of clothing layers was increased.

In another study involving cold weather clothing, Teitlebaum and Goldman[6] investigated the energy cost of wearing layers of clothing using metabolic rate as an index of energy expenditure. Eight men walked on a treadmill for 20 minutes at a speed of 5.6 or 8.0 km/hr (3.5 or 5.0 mi/hr) while wearing either all layers of Army cold weather clothing or carrying the equivalent weight on a waist belt. There was a significant increase of approximately 16% in the metabolic cost of walking with the multilayered clothing over the cost of just carrying the weight of the clothing. This was attributed to the frictional resistance ("friction drag") as one layer of material slid over another during movement or to interference with movement at the body's joints ("hobbling") produced by the clothing bulk.

In addition to the quantitative measures of performance on the task battery, a **questionnaire** was employed to obtain subjective reports regarding the clothing worn. Participants were asked to indicate those tasks in the battery in which the clothing worn interfered with performance and to rate the impact of various clothing design characteristics on performance. The questionnaire used here was identical to the one devised by Lockhart and Bensel for their cold weather clothing study and included scales of bipolar adjective pairs, such as comfortable-uncomfortable, heavy-light, and like-dislike. Lockhart and Bensel found that the comfort and the weight ratings became less positive as the number of clothing layers was increased.

[6]Teitlebaum, A. & Goldman, R. F. Increased energy cost with multiple clothing layers. *Journal of Applied Physiology*, 1972, *32*. 743-744.

Although only 20 women participated in the present study, it was decided to acquire data on the fit of both the men's and the women's clothing from this limited sample. A rating sheet was devised on which garment length aspects could be rated as being acceptable, too long, or too short, and circumference aspects as acceptable, too loose, or too tight. A previous evaluation of the fitting and sizing of men's and women's cold weather clothing was conducted on a larger sample of 179 enlisted women.[7] All garments were found to be acceptable for wear by women. However, some test participants could not be fitted within the range of men's sizes. It was estimated that the extra small sizes of men's undershirt, wool shirt, and field coat were too large for approximately 15% of Army women, and that the extra small drawers and field trousers were too large for 3% of the women. The extra small parka and arctic trousers with liners were estimated to be too large for 25 and 9% of Army women, respectively.

[7]White, R. M. *Anthropometric analyses of women's cold weather clothing* (Research Study Rep. PA–8). Natick, MA: US Army Quartermaster Research and Development Center, August 1956.

METHOD

Subjects

The subjects were 20 women who volunteered to participate in this study. They ranged in age from 20 to 42 years with the mean age being 28 years. Body measurements were obtained for each woman in order to properly fit her with the clothing being tested. Descriptive statistics for these measures are presented in Table 1 and the mean dimensions of subjects wearing each clothing size are presented in Table 2.

Clothing

The items worn by the subjects over the course of the experiment are listed in Table 3. Combinations of these garments comprised the 10 clothing conditions tested. Pictures of the conditions are presented in Appendix A. The conditions and the approximate weight of each were:

1a. Men's, wool, cold weather shirt and trousers (Men's Wool)--2.580 kg (5.69 lb)

1b. Women's, wool, cold weather shirt and trousers (Women's Wool)--1.860 kg (4.10 lb)

2a. Men's wool shirt and trousers, men's field coat and trousers-- (Men's Wool & Men's Field)--5.170 kg (11.39 lb)

2b. Women's wool shirt and trousers, women's field coat and men's field trousers (Women's Wool & Women's Field)--3.900 kg (8.58 lb)

3a. Men's wool shirt and trousers, men's field coat and trousers with liners (Men's Wool & Men's Field/Liners)--5.825 kg (12.84 lb)

3b. Women's wool shirt and trousers, women's field coat with liner and men's field trousers with liner (Women's Wool & Women's Field/Liners)--4.790 kg (10.56 lb)

4a. Men's wool shirt and trousers, men's field coat and trousers with liners, men's parka and arctic trousers (Men's Wool & Men's Field/Liners & Men's Arctic)--7.355 kg (16.21 lb)

4b. Women's wool shirt and trousers, women's field coat with liner and men's field trousers with liner, men's parka and arctic trousers (Women's Wool & Women's Field/Liners & Men's Arctic)--6.320 kg (13.93 lb)

Table 1

Selected Body Dimensions of the Study Sample (n=20)

Measure	Mean	*s.d.*	Range	Min	Max
Stature (cm)	160.72	7.68	29.21	142.88	172.09
Waist Back Length (cm)	41.69	2.40	8.89	36.83	45.72
Waist Height (cm)	97.73	4.76	20.32	88.90	109.22
Crotch Height (cm)	72.01	4.08	17.14	61.60	78.74
Waist-Kneecap Length (cm)	54.80	4.02	15.24	45.72	60.96
Sleeve Outseam Length (cm)	54.81	2.78	10.79	48.90	59.69
Bust Circum (cm)	91.66	6.81	21.59	81.28	102.87
Waist Circum (cm)	73.15	6.90	24.13	63.50	87.63
Hip Circum (cm)	100.84	8.14	25.40	88.90	114.30
Weight (kg)	61.64	8.87	27.00	49.96	76.96

Table 2

Mean Dimensions of Subjects for Each Clothing Size

Size	*n*	Stature (cm)	Waist Back Length (cm)	Waist Height (cm)	Crotch Height (cm)	Waist-Kneecap Length (cm)	Sleeve Outseam Length (cm)	Bust Circum (cm)	Waist Circum (cm)	Hip Circum (cm)	Weight (kg)
Men's											
Short	14	156.98	40.73	95.52	70.21	53.25	53.81				
Regular	6	169.44	43.92	102.87	76.20	58.42	57.15				
Long	0	—	—	—	—	—	—				
X–Small	4							82.55	65.72	91.44	51.40
Small	10							90.87	70.99	98.30	59.30
Medium	6							99.06	81.70	111.34	72.37
Large	0							—	—	—	—
X–Large	0							—	—	—	—
Women's											
Regular	20	160.72	41.69	97.73	72.01	54.80	54.81				
Long	0	—	—	—	—	—	—				
8	0							—	—	—	—
10	4							82.55	65.72	91.44	51.40
12	3							86.15	67.73	95.25	58.16
14	5							91.44	71.12	98.55	57.91
16	2							96.52	75.57	102.24	64.51
18	3							97.37	77.89	109.64	70.53
20	3							100.75	85.51	113.03	74.21

Table 3

List of Clothing Items

Item	Federal Stock No.
Drawers, Mens, Cotton/Wool	8415–00–904–5119 to –5123
Undershirt, Mens, Cotton/Wool	8415–00–904–5134 to –5138
Trousers, Cold Weather, Wool Serge	8415–00–231–7199 to –7213
Shirt, Cold Weather, Wool/Nylon Flannel	8415–00–188–3791 to –3798
Suspenders, Trousers	8440–00–221–0852
Trousers, Mens, Cotton/Nylon Wind Resistant (field)	8415–00–265–0367 to –0378
Liner Trousers, Nylon Quilted (field)	8415–00–782–2886 to –2890
Coat, Mans, Cotton/Nylon Wind Resistant (field)	8415–00–782–2933 to –2945
Liner Coat, Mans, Nylon Quilted (field)	8415–00–782–2886 to –2890
Trousers, Mens, Cotton/Nylon (arctic)	8415–00–782–2948 to –2961
Liner Trousers, Nylon Quilted (arctic)	8415–00–782–2922 to –2930
Parka, Mans, Cotton/Nylon Oxford	8415–00–782–3216 to –3219
Liner Parka, Mans, Nylon Quilted	8415–00–782–2881 to –2885
Slacks, Womens, Wool Serge	8410–00–965–2233 to –2236
Shirt, Womans, Wool Flannel	8410–00–965–2220 to –2226
Coat, Womans, Cotton Wind Resistant (field)	8415–00–136–5091 to –5100
Liner Coat, Womans, Wool/Nylon Flannel	8415–00–965–2212 to –2217

5a. Men's wool shirt and trousers, men's field coat and trousers with liners, men's parka and arctic trousers with liners (Men's Wool & Men's Field/Liners & Men's Arctic/Liners)--8.195 kg (18.06 lb)

5b. Women's wool shirt and trousers, women's field coat with liner and men's field trousers with liner, men's parka and arctic trousers with liners (Women's Wool & Women's Field/Liners & Men's Arctic/Liners)--7.140 kg (15.74 lb)

Information regarding the physical characteristics of the clothing is presented in Appendix B. The data listed there are the prescribed, finished garment measurements as found in the military specification for each item. Detailed descriptions of garment design are presented in Appendix C.

Regardless of which clothing condition listed above was being tested, each woman wore the men's cold weather undershirt and drawers as underlying clothing. Gym shoes were also used throughout the study. Suspenders were worn over the wool, cold weather shirt and attached to the field trousers and to the arctic trousers as well, when the latter were worn. When only wool shirts and trousers were used, no suspenders were worn. The field coats and the parka were zipped or buttoned to the neck and all front snaps and the sleeve cuffs were closed. The waist and hemline drawcords of the parka were secured and the collars of the field coats were turned down. No hood or fur ruff was worn with the parka. The women's wool trousers are issued unhemmed to allow for individual length adjustment. For the purposes of this study, the legs of the women's wool trousers were turned up to the ankle on each subject. With this exception, none of the clothing items were altered to achieve a more acceptable fit and the subjects were not permitted to roll back or push up the sleeves of any garments which they may have considered to be too long.

Tasks

Fourteen tasks were used to assess the performance of the women in this experiment. A goniometer was used on six tasks to measure the angular displacement of various parts of the body. The goniometer is an instrument consisting of a rotatable pendulum mounted in front of a moveable 360° scale. Both the scale and the pendulum are mounted on a thin block which is attached to a long strap. Accurate use of the goniometer demands that the scale remain in an almost vertical plane so that the pendulum can rotate freely to the vertical. As generally used in this study, the goniometer was strapped in a vertical position to a part of the body and set to zero by turning the moveable scale until the 0° mark coincided with the pendulum. The subject was then instructed to move her body in a certain fashion and, when the maximum amplitude of movement was reached, the degrees of arc through which the body part had passed were read directly from the point on the scale with which the pendulum was then aligned.

The first eight of the tasks comprising the performance battery were used to measure the amplitude of movement at various body joints. The remaining tasks also involved such a flexibility component, as well as rate of movement, manual dexterity, and psychomotor coordination factors. The tasks were administered in a standard manner and in the same order for all subjects. There were four trials on the first 10 tasks and one trial on each of the remaining tasks. The tasks are briefly described below in order of presentation. Additional information regarding the battery and directions for administering the tests are presented in Lockhart and Bensel (see reference 2). Photographs of a subject performing each of the tasks are also included there.

Task 1. Standing Trunk Flexion.[8] The subject did a toe-touch while keeping her knees straight. The task was used to measure how far the subject could bend toward her toes, with higher scores indicating greater distances.

Task 2. Sitting Trunk Flexion (see reference 8). The subject sat on a bench with her legs straight out in front of her and touched her toes while keeping her knees straight. The task was used to measure how far the subject could bend toward her toes, with lower scores indicating greater distances.

Task 3. Upper Arm Abduction.[9] The goniometer was placed on the right arm above the elbow. The subject stood with her body touching the corner of a wall and the goniometer was set to zero. Both arms were raised sideward and upward as far as possible and the angular displacement was read, in degrees, from the goniometer.

Task 4. Upper Arm Forward Extension (see reference 8). The goniometer was placed on the right arm above the elbow. The subject stood erect with her arms against her sides and the elbows stiff. The goniometer was set to zero. The right arm was then raised as far forward and up as possible with the elbow being kept stiff and the angular displacement was read, in degrees, from the goniometer.

Task 5. Upper Arm Backward Extension (see reference 3). The goniometer was placed on the right arm above the elbow. The subject stood erect with her back against a wall, her arms at her sides, and her elbows stiff. She rotated her right arm until the

[8] Dusek, E. R. & Teichner, W. H. *The reliability and intercorrelations of eight tests of body flexion* (Tech. Rep. EP–31). Natick, MA: US Army Quartermaster Research and Development Center, May 1956.

[9] Dusek, E. R. *Encumbrance of arctic clothing* (Tech. Rep. EP–85). Natick, MA: US Army Quartermaster Research and Engineering Center, June 1957.

palm was facing out and the thumb was pointed dorsally. The goniometer was set to zero. The right arm was then raised backward as far as possible, with the elbow being kept stiff, and the angular displacement was read, in degrees, from the goniometer.

Task 6. Upper Leg Abduction (see reference 3). The goniometer was placed on the right leg above the knee. The subject stood erect with feet together and facing an upright support about one foot in front of her which she grasped with both hands. The goniometer was set to zero. The subject raised her right leg sideward and up as far as possible while keeping her leg straight and the angular displacement, in degrees, was read from the goniometer.

Task 7. Upper Leg Forward Extension (see reference 2). The subject stood erect with her back against a wall and her feet together. The goniometer was placed on the right leg above the knee and set to zero. Supporting herself with the left hand on the back of a chair, the subject raised her leg forward while keeping her knee stiff and angular displacement was read, in degrees, from the goniometer.

Task 8. Upper Leg 8ackward Extension (see reference 8). The goniometer was placed on the right leg above the knee. The subject stood facing and touching a wall with her right hip and leg at the edge of the wall and the goniometer was set to zero. The right leg was then moved as far backward as possible while the subject maintained contact with the wall. The maximum angular displacement was read, in degrees, from the goniometer.

Task 9. Pursuit Rotor.[10] This was a test of psychomotor coordination involving the arm and the shoulder. The subject was required to keep the tip of a stylus, which was held in the preferred hand, in contact with a disc which was 1.25 cm (.49 in.) in diameter and was embedded in the surface of a turntable. The disc was located 2.0 cm (.79 in.) from the edge of the turntable which was 26.0 cm (10.24 in.) in diameter and rotated as a speed of 60 rev/min. The score was the total time on target during a 30-sec trial.

Task 10. Railwalking.[11] This was a test of psychomotor coordination involving several sensorimotor groups. A rail, 365 cm (143.70 in.) long and 1.90 cm (.75 in.) thick, was marked at intervals of 1.0 cm (.39 in.). While grasping her hands behind her back, the subject was to walk the rail in heel to toe fashion. Her score was the distance from the start of the rail to the toe of the last foot that remained on the rail when she lost her balance.

[10] Melton, A. W. *Apparatus tests* (AAF Aviation Psychology Program Research Report No. 4). Washington, D.C.: Government Printing Office, 1947.

[11] Dusek, E. R. *Standardization of tests of gross motor performance* (Tech. Rep. EP–81). Natick, MA: US Army Quartermaster Research and Engineering Center, January 1958.

Task 11. O'Connor Fine Finger Dexterity Test.[12] In this test of manual dexterity, the subject was required to put three pins in each of 20 holes using only one hand. The pins were 2.5 cm (.98 in.) long and 0.1 cm (.04 in.) in diameter. The holes were 0.5 cm (.20 in.) in diameter. The score was the time required, in seconds, to complete the task.

Task 12. Purdue Pegboard Assembly Test.[13] In this test of manual dexterity, the subject was required to construct 12 pin-washer-collar-washer assemblies in a pegboard using both hands simultaneously to accomplish the task. Her score was the time required, in seconds, to complete the assemblies.

Task 13. Front Horizontal Striking (see reference 2). This test was used as a measure of rate of movement. The height of a horizontally-mounted cable was adjusted to the subject's shoulder height and the distance between two stops mounted on the cable was such that the movement of the preferred arm subtended a 30° angle when the subject was positioned in front of one stop and an arm's length from the cable. Facing the cable, the subject stood an arm's length from it with the shoulder of her preferred hand in front of one stop and moved a striker between the stops as rapidly as possible. Her score was the number of times in 60 sec that she struck the stop in front of her after striking the far stop. The subject was to move only her shoulder and arm while striking across her body and was to keep her arm straight at all times.

Task 14. Side Horizontal Striking (see reference 2). This test was used as a measure of rate of movement. As in Front Horizontal Striking, the height of a horizontally-mounted cable was adjusted to the subject's shoulder height and the distance between two stops mounted on the cable was such that the movement of the preferred arm subtended a 30° angle when the subject was positioned in front of one stop and an arm's length from the cable. The subject stood with the side of her body facing the cable and an arm's length from it with the shoulder of her preferred hand in front of one stop. She was to move a striker between the stops as rapidly as possible. Her score was the number of times in 60 sec that she struck the stop in front of her after striking the far stop. The subject was to move only her shoulder and arm while striking back away from her body and was to keep her arm straight at all times.

[12] Hines, M. & O'Connor, J. A measure of finger dexterity. *Journal of Personnel Research*, 1926, *4*, 379–382.

[13] Purdue Research Foundation. *Examiner manual for the Purdue pegboard*. Chicago: Science Research Associates, 1948.

In addition to employing this task battery to obtain quantitative performance data, a questionnaire was administered to the women in order to elicit their subjective opinions regarding those tasks comprising the battery which were most affected by the clothing conditions. They were also asked to rank and to rate the extent to which a number of clothing design characteristics may have aided or impaired their performances. A complete copy of the questionnaire is presented in Appendix D.

Heart rate was recorded at two intervals during the performance of the task battery. A silver cup electrode for monitoring heart rate was affixed to the ventral surface of each lower arm and connected to a wide-band, a.c. preamplifier (Grass Instruments, Model 7P3), the output of which was recorded on a polygraph (Grass Instruments, Model 7).

Procedure

Before testing began, measurements of selected body dimensions were obtained for each woman (Table 1) and she was issued appropriately-sized clothing items (Table 3). The selection of clothing sizes to be tried on by a subject was made according to the sizing charts for these items.[14] The charts are presented in Appendix E. Each woman donned clothing in the sizes indicated and the fit of the garments was rated by an experienced clothing designer using the format presented in Appendix F. The designer also determined at this time if other sizes should be tried in order to achieve a more acceptable fit.

Prior to testing, the subjects also received practice on four tasks in the test battery: Railwalking, the Pursuit Rotor, the O'Connor Finger Dexterity, and the Purdue Pegboard Assembly Tests. The practice phase generally extended over four days and included two sessions per day. At each session, the subject received five trials on each of the above tasks with the exception of the Pursuit Rotor, on which she received 10 trials. During this time, the women were also familiarized with all the tasks in the battery, the questionnaire, and the general procedure to be followed during the experimental sessions. The subjects wore slacks, blouses, and gym shoes and the temperature in the test chamber was 20°C (68°F).

For the experimental sessions, the test chamber was maintained at 10°C (50°F). Each woman participated at the same time each day, either in the morning or in the afternoon, for five consecutive days. At each session, she performed all tasks in the battery under

[14] Department of the Army. *Cold weather clothing and sleeping equipment* (Tech. Manual 10–275). Washington, D.C.: Headquarters, Department of the Army, July 1968.

two of the 10 clothing conditions. Before beginning the first task in the battery, the subject was outfitted in gym shoes, the men's cold weather undershirt and drawers, and the remaining clothing for the condition. After heart rate had been recorded for 60 sec (reading 1), the subject was instructed in and performed the first task, Standing Trunk Flexion. The subject performed the remaining tasks in sequence. After completing the final task, Side Horizontal Striking, the subject stood while her heart rate was again recorded for 60 sec (reading 2) and she was then given a rest of approximately 10 minutes. During the rest, the subject completed the questionnaire. In responding to the questionnaire, she was instructed to analyze the clothing she was wearing and to indicate how these items may have affected her performance. This procedure was repeated for subsequent clothing conditions. Approximately 40 minutes were required to complete all the tasks in the battery.

For the experimental sessions, the 20 women were divided into 10 groups of two women each. Each pair of women received a different sequence of exposure to the clothing conditions. The 10 sequences, presented in Table 4, were based upon a Random Square. Of the two women in a group, one participated in the morning and the other in the afternoon.

After completion of all data collection, an analysis of variance was performed on each of the 14 tasks in the battery. For the experimental design, clothing conditions involving any of the items designed for women were considered to be women's ensemble conditions while those with only men's items were considered to be men's ensemble conditions. The analyses performed on the data were of the following form: Subjects (1–20) by clothing ensemble (Men's, Women's) by clothing layers (Wool, Wool & Field, Wool & Field/Liners, Wool & Field/Liners & Arctic, Wool & Field/Liners & Arctic/Liners). Because of equipment difficulties on the Pursuit Rotor Test, the data for only 15 subjects were available for analysis. The raw data used in the analyses of Tasks 1 through 10 of the battery were the mean scores obtained by summing over the four trials on each task. On the remaining tasks, the raw data were the scores obtained on the single trial administered.

For the heart rate measure, the raw data from the two readings taken under each clothing condition were analyzed according to the same form of analysis of variance used for the task data. However, the heart rate raw data analysis also included the reading (1, 2) variable. For the questionnaire, the responses of all women to each question under each clothing condition were compiled and summarized. The fit ratings on each clothing item were also compiled.

Teble 4

Order in Which the Ten Clothing Conditions Were Presented to Eech Subject

Sequence No.	Subject No.	Clothing Condition* 1e	1b	2e	2b	3a	3b	4a	4b	5a	5b
1	1,11	8	6	5	2	1	3	10	9	4	7
2	2,12	9	7	3	10	8	1	6	5	2	4
3	3,13	5	2	9	1	10	6	8	4	7	3
4	4,14	7	3	8	5	2	9	4	1	10	6
5	5,15	3	5	1	6	7	4	2	8	9	10
6	6,16	1	4	2	7	6	5	3	10	8	9
7	7,17	2	8	6	4	9	10	7	3	5	1
8	8,18	10	9	4	8	3	7	1	2	6	5
9	9,19	4	10	7	3	5	2	9	6	1	8
10	10,20	6	1	10	9	4	8	5	7	3	2

*1a = Men's Wool
1b = Women's Wool
2a = Men's Wool & Men's Field
2b = Women's Wool & Women's Field
3a = Men's Wool & Men's Field/Liners
3b = Women's Wool & Women's Field/Liners
4a = Men's Wool & Men's Field/Liners & Men's Arctic
4b = Women's Wool & Women's Field/Liners & Men's Arctic
5a = Men's Wool & Men's Field/Liners & Men's Arctic/Liners
5b = Women's Wool & Women's Field/Liners & Men's Arctic/Liners

RESULTS

Task Battery Data

The results of the analyses of variance performed on the 14 tasks comprising the battery are presented in Table 5. The tasks are numbered and listed in the order in which they were performed. Clothing layers had a significant effect on the data of all tasks with the exception of the O'Connor Finger Dexterity Test (Task 11). The results of the Newman-Keuls multiple comparison tests performed on the means for the 13 tasks with significant layer effects are presented in Table 6. There was a significant main effect attributable to clothing ensemble on four tasks: Standing and Sitting Trunk Flexion (Tasks 1 and 2), Upper Arm Abduction (Task 3), and the Pursuit Rotor (Task 9) (Table 5). No significant interactions between clothing ensemble and layers were obtained in any of the analyses of variance performed on the task data (Table 5). The mean scores on each task as a function of ensemble type and clothing layers are presented in Figures 1 through 14.

Two flexibility tasks in the battery required bending at the waist. These were Standing and Sitting Trunk Flexion (Tasks/Figures 1 and 2). Both tasks were affected similarly by ensemble type and clothing layers. Use of the women's ensemble resulted in significantly better performance than was obtained when the men's ensemble was worn and performance levels decreased significantly with the addition of each layer of clothing (Table 6).

The next three flexibility tasks included in the performance battery involved movement of the upper arm and the effects of clothing layers and ensembles varied among these movements. Upper Arm Abduction (Task/Figure 3) was the only one of these tasks which was affected by the type of ensemble worn. Here, the mean extent of arm abduction was greater with the women's (112.0°) than with the men's ensemble (102.0°). With regard to clothing layers, performance on Upper Arm Abduction was best when the wool shirt and trousers were worn alone and was significantly worsened when the field coat and trousers were added. The use of liners in the field layer did not yield an additional impairment, but the presence of the arctic parka and trousers resulted in a further significant performance decrement as did the wearing of liners in the arctic layer (Table 6).

The impact of the layer variable on the Upper Arm Forward Extension Task (Task/Figure 4) was not as great as that on Upper Arm Abduction. The wearing of the wool shirt and trousers alone resulted in significantly more forward arm extension relative to that for the two conditions in which the arctic clothing was used, but the scores for the wool shirt and trousers did not differ from those for the two conditions in which the field coat and trousers comprised the outermost layer. The field clothing scores were significantly higher than those achieved when liners were worn in the arctic parka and trousers, but the arctic conditions did not differ from each other (Table 6).

Table 5

Analyses of Variance of Task Battery Data

Source of Variance	df	Task Number 1 MS	1 F	2 MS	2 F	3 MS	3 F	4 MS	4 F
Subjects (Ss)	19	73.14		70.45		1167.08		819.86	
Ensemble (E)	1	16.49	14.58**	16.05	13.18**	5038.07	13.14**	82.56	<1.00
Layers (L)	4	78.71	67.48***	85.29	43.14***	7091.89	64.43***	1291.23	7.08**
Ss x E	19	1.13		1.22		383.50		378.21	
Ss x L	76	1.17		1.98		110.07		182.28	
E x L	4	0.70	1.09	0.34	<1.00	108.22	<1.00	129.76	<1.00
Ss x E x L	76	0.64		0.87		109.32		174.41	

Source of Variance	df	Task Number 5 MS	5 F	6 MS	6 F	7 MS	7 F
Subjects (Ss)	19	226.16		470.16		554.23	
Ensemble (E)	1	15.22	<1.00	11.23	<1.00	12.66	<1.00***
Layers (L)	4	475.51	7.40***	391.94	7.43***	886.09	19.00
Ss x E	19	85.62		89.91		77.56	
Ss x L	76	64.21		52.75		46.62	
E x L	4	36.08	1.11	67.35	1.10	58.20	1.47
Ss x E x L	76	32.45		61.23		39.52	

Source of Variance	df	Task Number 8 MS	8 F	9a MS	9a F	10 MS	10 F	11 MS	11 F
Subjects (Ss)	19	236.16		158.87		28342.81		643.56	
Ensemble (E)	1	2.27	<1.00	47.33	12.50**	17.36	<1.00	21.25	<1.00
Layers (L)	4	81.05	2.75*	31.68	6.84***	6953.25	4.42**	91.75	1.71
Ss x E	19	50.57		3.79		1290.82		60.19	
Ss x L	76	29.42		4.63		1574.22		53.64	
E x L	4	41.28	1.65	1.90	<1.00	2174.76	2.00	38.90	<1.00
Ss x E x L	76	25.07		2.81		1090.03		44.98	

Table 5

Analyses of Variance of Task Battery Data (cont'd)

Source of Variance	df	Task Number 12 MS	F	13 MS	F	14 MS	F
Subjects (Ss)	19	108.98		2498.04		2003.20	
Ensemble (E)	1	1.02	<1.00	378.12	1.57	547.80	2.36
Layers (L)	4	77.51	4.53**	735.58	5.97***	885.47	7.89***
Ss x E	19	19.11		240.86		232.20	
Ss x L	76	17.12		123.16		112.23	
E x L	4	6.98	<1.00	221.76	1.53	27.53	<1.00
Ss x E x L	76	13.32		144.55		119.63	

***$p<.001$
**$p<.005$
*$p<.05$

[a]*df* = 14, 1, 4, 14, 56, 4, 56, respectively.

Table 6

Mean Score for Tasks under Each Clothing Layer Condition

Task	Layer Condition*				
	1	2	3	4	5
1. Standing Trunk Flexion (cm)	37.39	33.12	32.08	29.59	28.15
	1	2	3	4	5
2. Sitting Trunk Flexion (cm)	4.95	8.53	9.63	12.12	14.76
	1	2	3	4	5
3. Upper Arm Abduction (deg)	127.92	108.62	106.20	100.29	92.06
	1	3	2	4	5
4. Upper Arm Forward (deg) Extension	144.37	138.99	138.83	134.51	129.16
	1	2	3	4	5
5. Upper Arm Backward Extension (deg)	42.10	39.19	37.34	37.01	32.66
	1	2	4	3	5
6. Upper Leg Abduction (deg)	47.22	46.84	43.45	42.05	39.92
	1	2	3	4	5
7. Upper Leg Forward Extension (deg)	54.98	51.10	47.26	46.59	42.61
	2	1	4	3	5
8. Upper Leg 8ackward Extension (deg)	27.65	26.64	26.17	25.94	23.78
	1	2	4	3	5
9. Pursuit Rotor (sec)	15.24	14.24	13.51	13.28	12.52
	1	2	4	3	5
10. Railwalk (cm)	157.21	148.44	145.63	133.12	123.81
	1	3	2	4	5
12. Purdue Pegboard Assembly (sec)	48.67	49.06	50.22	50.77	52.15

Table 6

Mean Score for Tasks under Each Clothing Layer Condition (cont'd)

Task	Layer Condition*				
	1	3	4	2	5
13. Front Horizontal Striking	102.88	98.22	95.65	95.38	91.20
	1	2	3	4	5
14. Side Horizontal Striking	103.12	98.28	95.32	95.32	90.28

* 1 = Wool
2 = Wool & Field
3 = Wool & Field/Liners
4 = Wool & Field/Liners & Arctic
5 = Wool & Field/Liners & Arctic/Liners

NOTE: Layer conditions not connected by the same line are significantly different ($p<.05$).

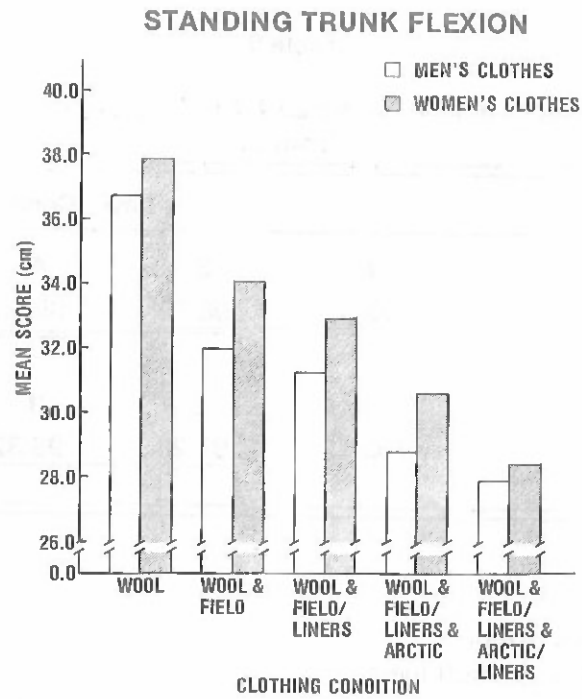

Figure 1. Mean score on Standing Trunk Flexion (Task 1) as a function of clothing condition.

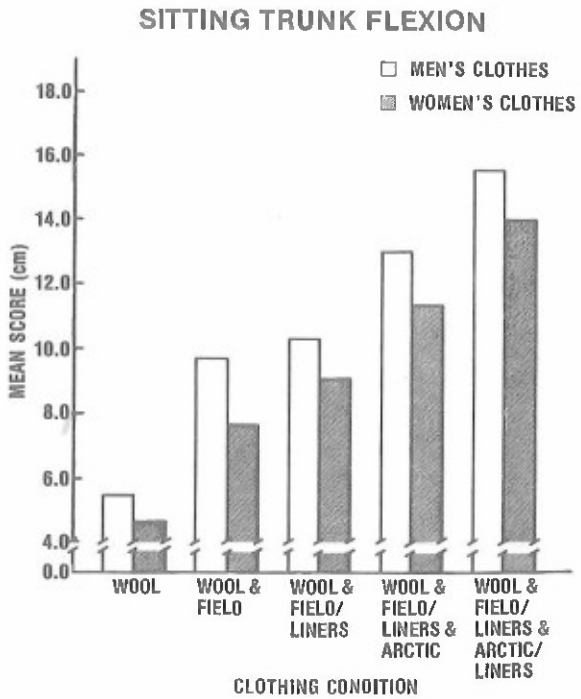

Figure 2. Mean score on Sitting Trunk Flexion (Task 2) as a function of clothing condition.

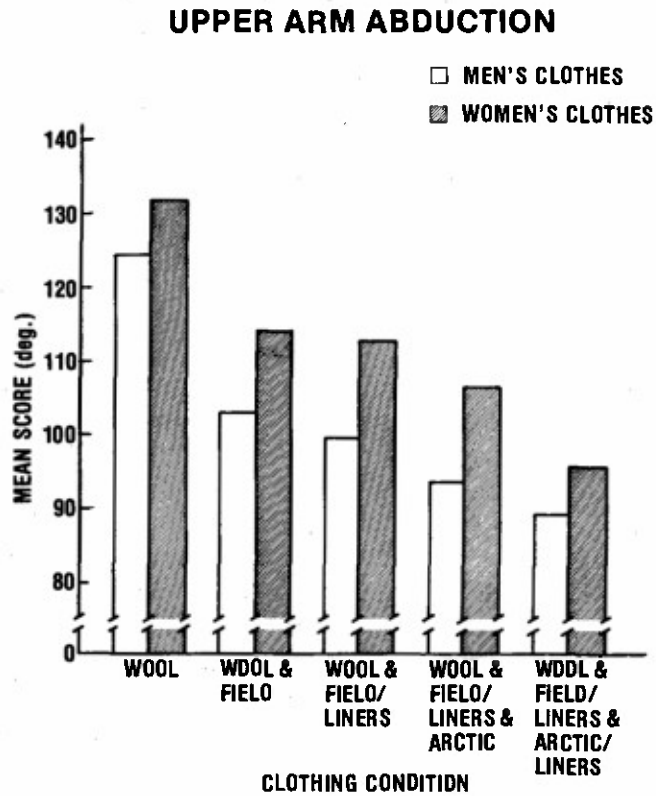

Figure 3. Mean score on Upper Arm Abduction (Task 3) as a function of clothing condition.

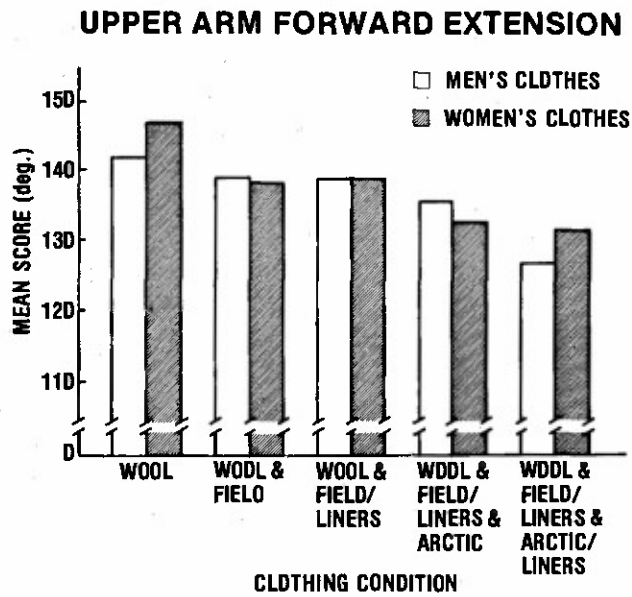

Figure 4. Mean score on Upper Arm Forward Extension (Task 4) as a function of clothing condition.

The effects of clothing layers on Upper Arm Backward Extension (Task/Figure 5) were somewhat similar to the findings for the forward arm extension movement insofar as the scores for the conditions in which the field coat and trousers comprised the outermost layer and the condition in which the arctic parka and trousers were worn without liners did not differ significantly from each other. However, the addition of the arctic liners resulted in a mean score which was significantly lower than that achieved under any of the other levels of the layer variable and backward arm extension when the wool shirt and trousers were worn was superior to all conditions except the field coat and trousers without liners.

The three remaining flexibility tasks in the battery involved leg movements. None of these tasks were affected by the type of ensemble worn (Table 5) and, again, the effects of clothing layers varied with the movement required. For the Upper Leg Abduction movement (Task/Figure 6), performance level did not decrease significantly relative to the wool condition until liners were added to the field layer and the use of the arctic clothing did not result in any further performance decrements (Table 6). On Upper Leg Forward Extension (Task/Figure 7), there was a significant decrement in leg movement as each layer was added to the wool shirt and trousers, with the exception of the addition of the arctic parka and trousers to the field clothing (Table 6). For the Upper Leg Backward Extension Task (Task/Figure 8), scores achieved when all clothing layers were worn were significantly lower than the best scores which were those achieved when the field layer was used without liners. There were no other significant differences among layer conditions on this task (Table 6).

Scores on both of the psychomotor coordination tests included in the battery were significantly affected by the layer variable and one of these, the Pursuit Rotor (Task/Figure 9), was also influenced by the clothing ensemble worn. Use of the women's ensemble resulted in a significantly higher mean time-on-target score (14.3 sec) than did use of the men's ensemble (13.2 sec). With regard to clothing layers, the highest Pursuit Rotor scores occurred when the wool shirt and trousers were worn alone. The addition of the field layer resulted in a slight, but not significant, performance decrement. However, scores for the remaining layer conditions were significantly lower than those for the wool shirt and trousers. The use of liners in the field layer or the use of the arctic parka and trousers did not lower scores significantly relative to those achieved with the field layer alone, but the addition of arctic liners did. Also, the condition in which liners were worn in the field layer did not result in scores which were significantly superior to those obtained for either of the arctic clothing conditions (Table 6).

On Railwalking (Task/Figure 10), the other psychomotor coordination test included in the battery, the best mean score was again achieved when the wool shirt and trousers were worn alone. It was significantly higher than that for the field clothing with liners or for the arctic clothing with liners, and the latter condition yielded a mean score which was significantly lower than all others. There were no other differences among the layer conditions (Table 6).

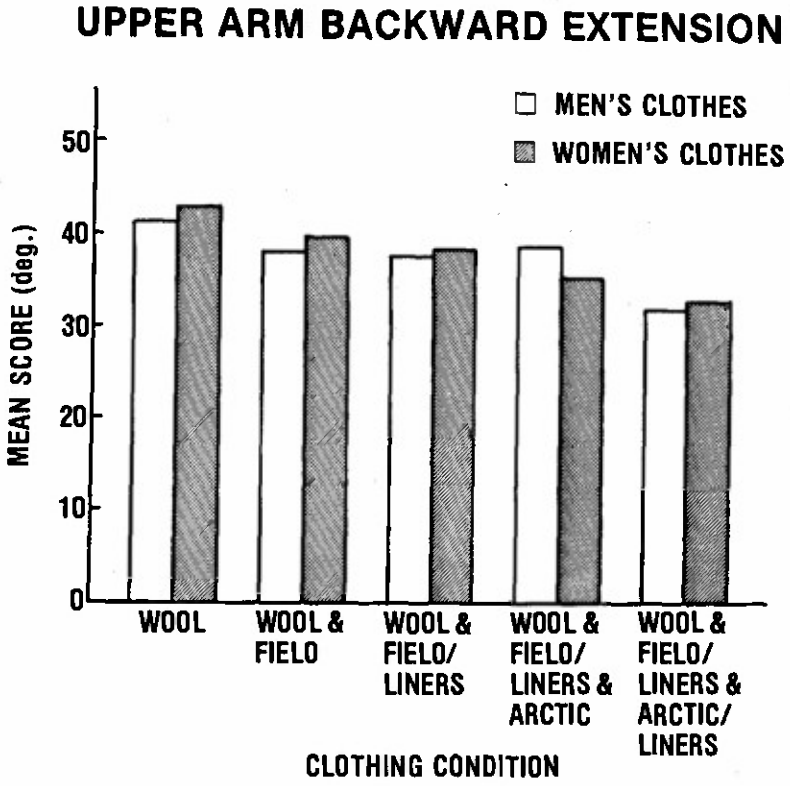

Figure 5. Mean score on Upper Arm Backward Extension (Task 5) as a function of clothing condition.

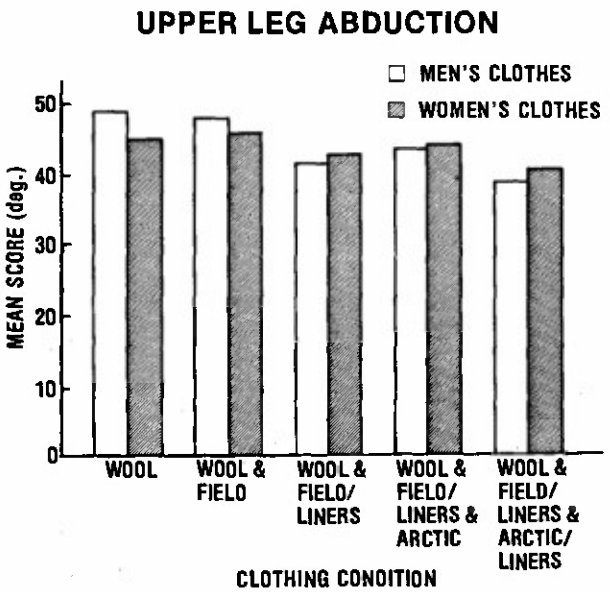

Figure 6. Mean score on Upper Leg Abduction (Task 6) as a function of clothing condition.

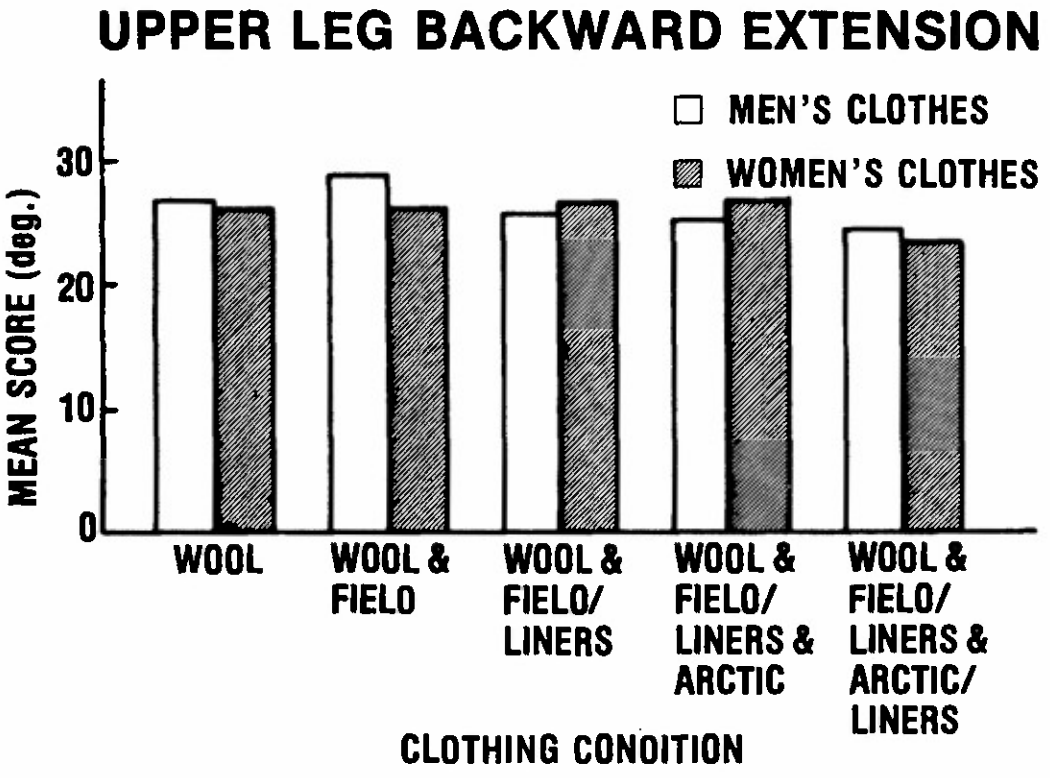

Figure 7. Mean score on Upper Leg Forward Extension (Task 7) as a function of clothing condition.

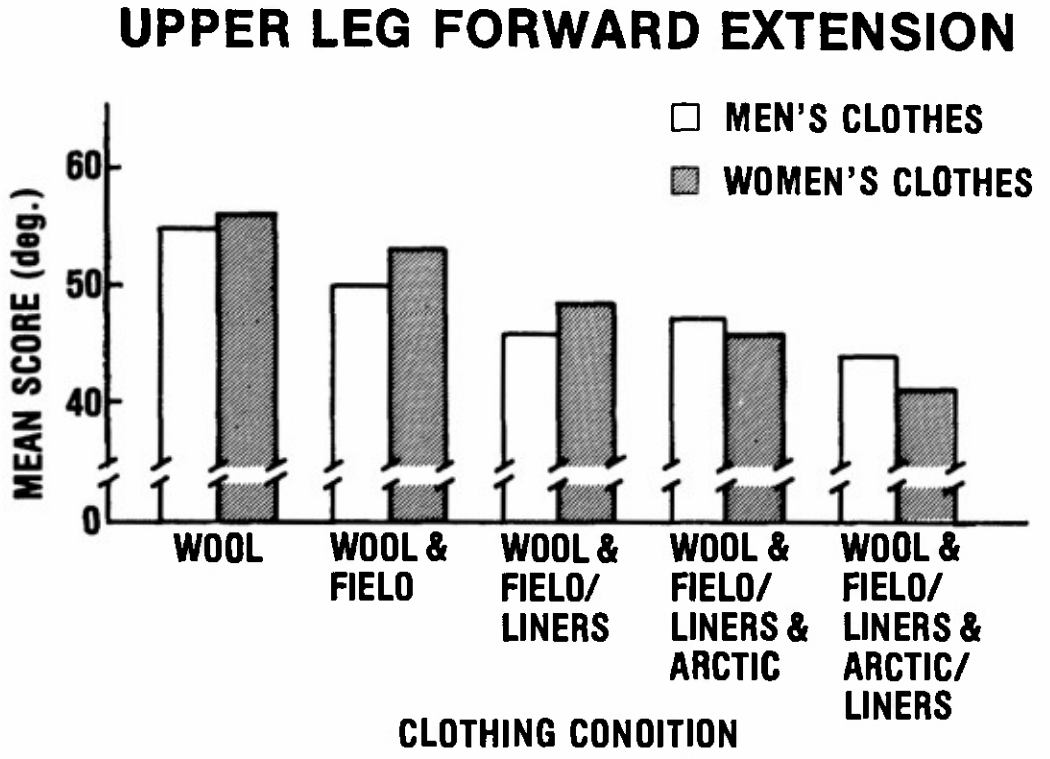

Figure 8. Mean score on Upper Leg Backward Extension (Task 8) as a function of clothing condition.

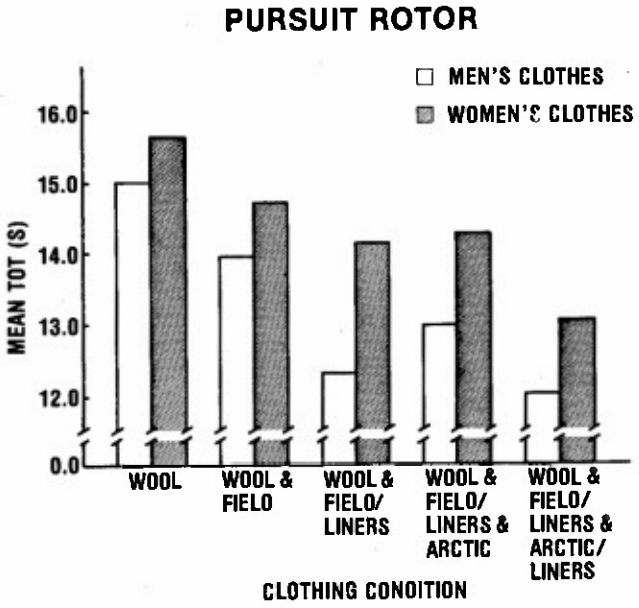

Figure 9. Mean Pursuit Rotor time on target (Task 9) as a function of clothing condition.

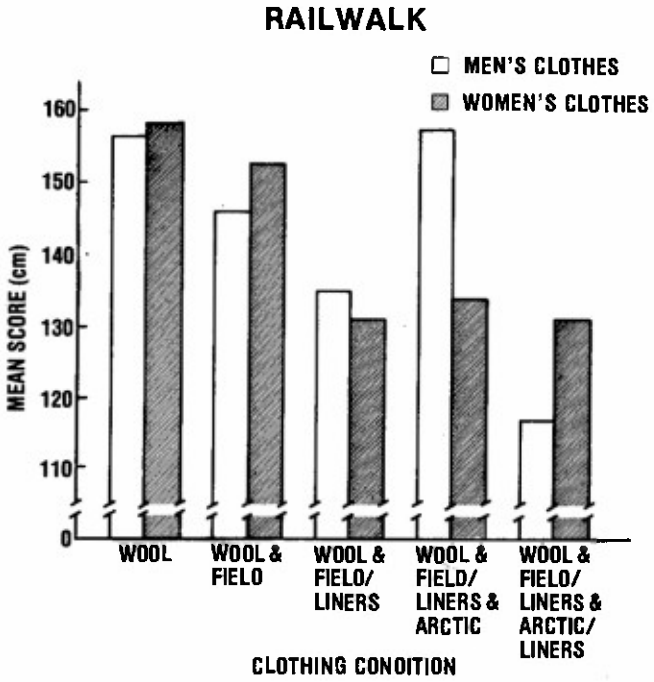

Figure 10. Mean Railwalking score (Task 10) as a function of clothing condition.

Of the two manual dexterity tests included in the battery, the O'Connor Test (Task/Figure 11) was not significantly affected by either the ensemble or the clothing variable. However, the Purdue Pegboard Assembly Test (Task/Figure 12), the task that required the simultaneous use of both hands, was significantly affected as a function of the clothing layers worn. The fastest mean times to task completion occurred when the wool shirt and trousers or the field clothing with liners were used. These scores were significantly better than the slowest time to task completion which occurred when all clothing layers were worn. There were no other significant differences among layer conditions on this task (Table 6).

The rate of movement tests investigated in this study, Front and Side Horizontal Striking (Tasks/Figures 13 and 14), also yielded significant layer effects. On the Front Striking, the wool condition scores were highest and were superior to all others except those achieved when the field coat and trousers with liners were worn. The lowest mean score occurred when the arctic layer was worn with liners. Scores under this condition were not significantly different from those for the field clothing without liners or the arctic parka and trousers without liners (Table 6). On the Side Horizontal Striking Task (Task/Figure 14), the mean score for the wool clothing was significantly better than all others and the mean score when all layers were worn was significantly worse than all others. There were no significant differences among the scores for the intervening layer conditions (Table 6).

Heart Rate Data

The effect of time was significant in the analysis of variance performed on the heart rate scores (Table 7). The second heart rate reading, taken after the completion of the test battery, was higher (92.1 beats/min) than the first heart rate reading taken prior to initiation of the test battery (87.6 beats/min). The interaction between reading and ensemble type also approached significance ($p<.10$) and a plot of the means involved in this interaction is presented in Figure 15. This interaction indicated that there was a tendency for the difference between the reading 1 and the reading 2 heart rates to be greater when the women's ensemble was worn than when the men's ensemble was used. Thus, there was a greater increase in heart rate over the course of the task battery for the women's ensemble than for the men's ensemble.

Questionnaire Data

On the first question of Section I (Appendix D), the subjects were asked to rank from 1 to 3 the three flexibility movements and the three psychomotor tasks which were most impaired by each clothing condition. Scores of 3, 2, and 1 were assigned to ranks of 1, 2, and 3, respectively, and the sums of these scores across subjects for each task and clothing condition are presented in Table 8. Among the flexibility tasks, the rated difficulty of Standing and Sitting Trunk Flexion and Upper Arm Abduction generally

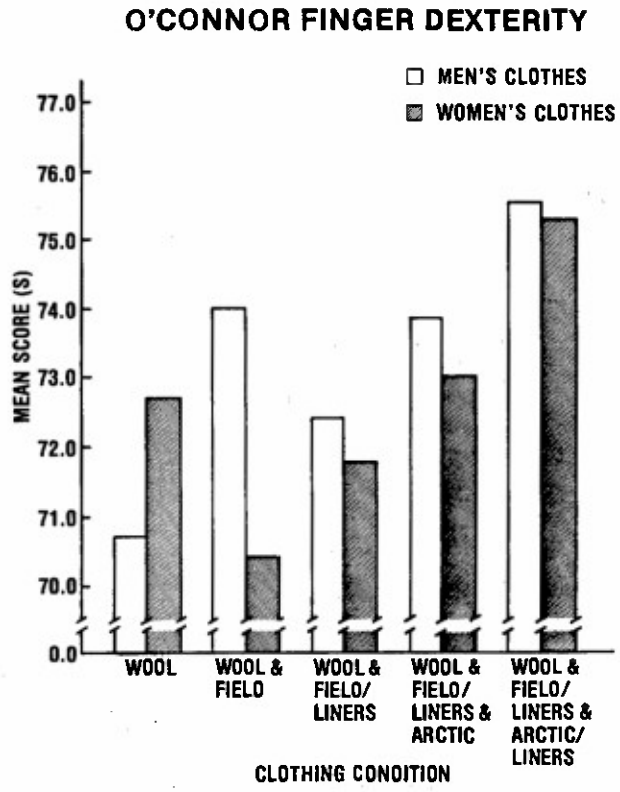

Figure 11. Mean O'Connor Finger Dexterity Test score (Task 11) as a function of clothing condition.

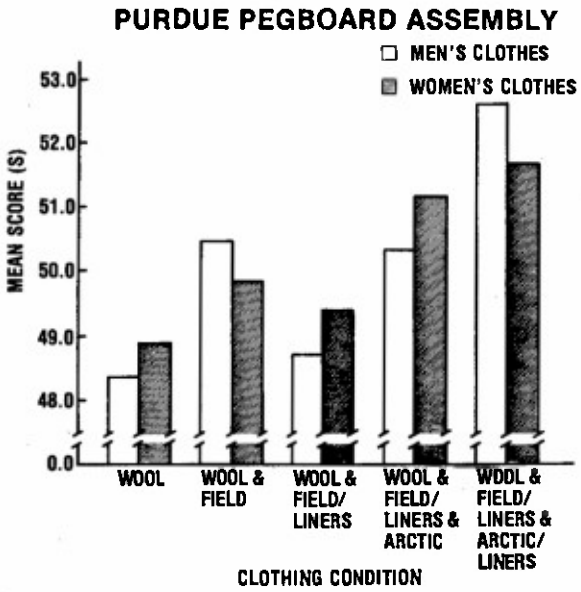

Figure 12. Mean Purdue Pegboard Assembly Test score (Task 12) as a function of clothing condition.

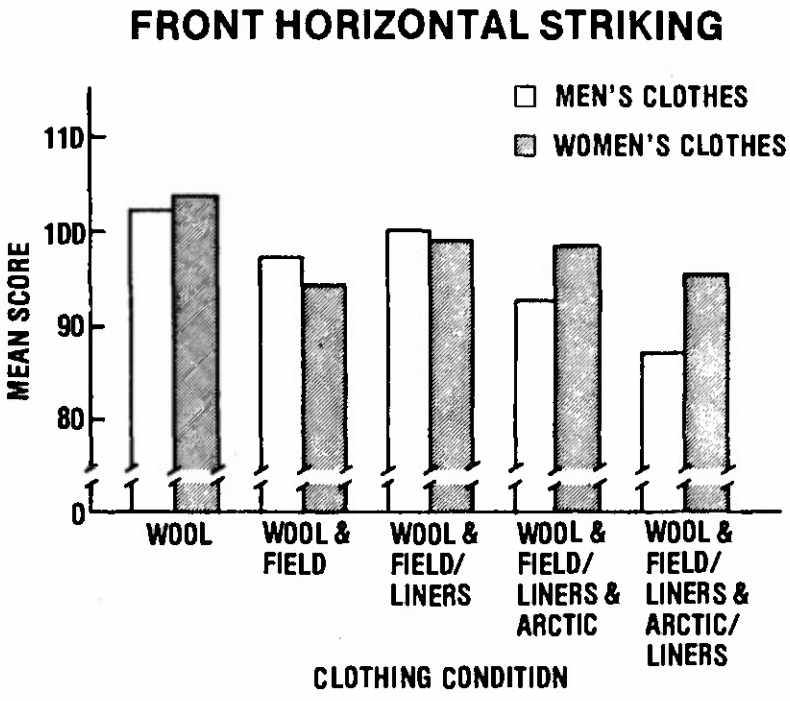

Figure 13. Mean score on Front Horizontal Striking (Task 13) as a function of clothing condition.

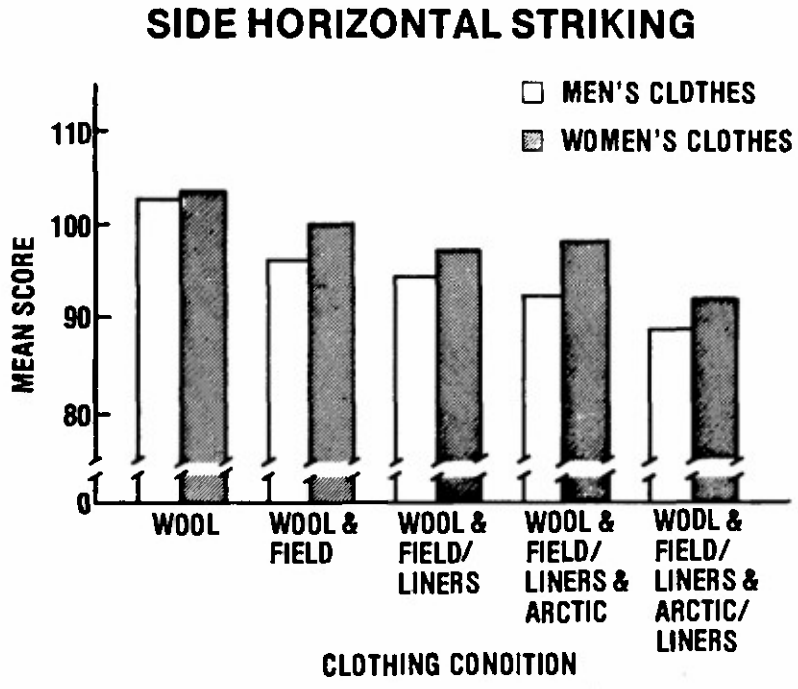

Figure 14. Mean score on Side Horizontal Striking (Task 14) as a function of clothing condition.

Table 7

Analysis of Variance of Heart Rate Data

Source Variance	*df*	*MS*	*F*	*p*
Subjects (Ss)	19	2172.95		
Ensemble (E)	1	175.56	2.70	
Layers (L)	4	112.99	1.14	
Reading (R)	1	1984.70	37.90	.001
Ss x E	19	64.89		
Ss x L	76	98.84		
E x L	4	158.05	1.77	
Ss x R	19	52.36		
E x R	1	87.42	4.28	.10
L x R	4	11.36	<1.00	
Ss x E x L	76	89.44		
Ss x E x R	19	20.41		
Ss x L x R	76	14.99		
E x L x R	4	25.54	1.40	
Ss x E x L x R	76	18.22		

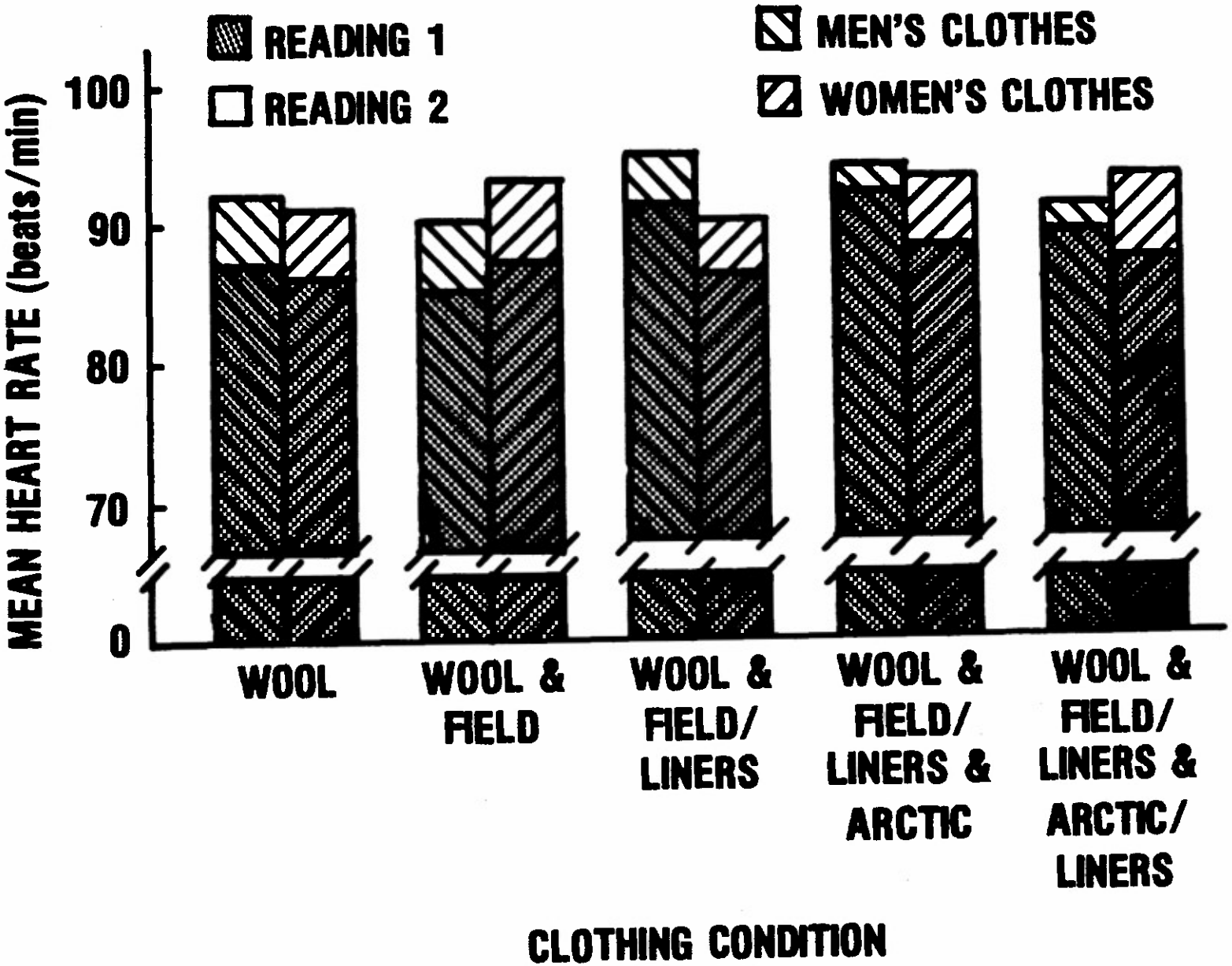

Figure 15. Mean Heart Rate as a function of clothing condition and reading.

Table 8

Subjects' Summed Ratings of the Impairment of Each Task by Each Clothing Condition

Battery	Clothing Condition* 1a	1b	2a	2b	3a	3b	4a	4b	5a	5b
Movements										
Standing Trunk Flexion	8	3	22	18	26	23	29	31	34	40
Sitting Trunk Flexion	13	4	27	23	24	32	24	29	39	37
Upper Arm Abduction	6	0	12	7	26	6	18	19	20	12
Upper Arm Forward	5	3	6	5	8	1	9	4	5	3
Upper Arm 8ackward	9	6	15	12	9	11	7	8	7	8
Upper Leg Abduction	7	19	11	7	3	14	5	6	3	0
Upper Leg Forward	7	14	4	15	9	14	10	3	2	5
Upper Leg 8ackward	17	22	10	11	12	14	16	13	11	11
Tasks										
Pursuit Rotor	8	8	12	5	24	11	21	17	21	15
Railwalking	4	7	12	16	15	27	15	19	20	29
O'Connor	15	15	34	17	31	18	23	26	28	23
Purdue Pegboard	7	3	18	3	14	2	8	8	10	8
Front Horizontal Striking	13	22	12	18	14	17	25	19	19	23
Side Horizontal Striking	12	16	16	21	18	23	18	20	18	13

*1a = Men's Wool
1b = Women's Wool
2a = Men's Wool & Men's Field
2b = Women's Wool & Women's Field
3a = Men's Wool & Men's Field/Liners
3b = Women's Wool & Women's Field/Liners
4a = Men's Wool & Men's Field/Liners & Men's Arctic
4b = Women's Wool & Women's Field/Liners & Men's Arctic
5a = Men's Wool & Men's Field/Liners & Men's Arctic/Liners
5b = Women's Wool & Women's Field/Liners & Men's Arctic/Liners

increased as the number of layers increased, regardless of the ensemble worn. The ratings given to the remaining flexibility movements did not vary systematically as a function of clothing layers. When the ratings given the men's and the women's ensembles were contrasted, it was found that the men's ensemble was judged to have impaired performance of Upper Arm Abduction and Forward Extension more than the women's had, whereas the opposite was the case for Upper Leg Abduction and Forward Extension.

Among the psychomotor coordination tasks, the ratings given to the Pursuit Rotor and the O'Connor Finger Dexterity Tests increased as the number of clothing layers was increased. The judged difficulty of the other psychomotor tasks did not vary systematically with layers. The Pursuit Rotor Test and the two tests of manual dexterity were rated as being more impaired by the men's than by the women's ensemble. Railwalking was judged to be more difficult when the women's ensemble was worn.

For Question 2 of Section I (Appendix D), the subjects ranked from 1 to 3 those clothing design characteristics which impaired their performance on the flexibility and the psychomotor tasks. Scores of 3, 2, and 1 were assigned to ranks of 1, 2, and 3, respectively, and the sums of these scores across subjects for each design characteristic and clothing condition are presented in Table 9. For the flexibility tasks, the design characteristics of bulk and waist flexibility received the highest ratings regardless of the clothing being worn and these ratings increased as the number of clothing layers was increased. The judged importance of weight, waist flexibility, and collar flexibility in impairing performance on the flexibility movements also increased as a function of clothing layers. Bulk, waist flexibility, and weight were given higher ratings when the men's ensemble items were used, while collar and shoulder fit were rated higher when the women's ensemble items were worn.

For the psychomotor tasks, bulk and protruding parts received the highest ratings with the ratings for the latter changing little as a function of clothing layers. The importance of weight, waist flexibility, and bulk in impairing task performance was judged to increase with clothing layers. The remaining design characteristics did not vary systematically as a function of layers. The design characteristics of bulk, weight, stability, and protruding parts were generally rated higher for the men's than for the women's ensemble. Collar fit, shoulder fit, and shoulder flexibility were generally rated higher for the women's ensemble.

Questions 1 and 2, Section II, of the questionnaire (Appendix D) were restatements of the previous question. However, the subjects were to rate each design characteristic on a five-point scale from "no importance" to "extreme importance" in impairing or in aiding performance. Mean ratings were obtained for each design characteristic by assigning a numerical value to each point on the scale, from "1" for "no importance to "5" for "extreme importance", and multiplying the value by the number of subjects choosing that point on the scale. Therefore, the higher the mean rating, the greater the importance

Table 9

Subjacts' Summed Ratings of the Importance of Each Design Characteristic in Impairing Performance for Each Clothing Condition

Design Characteristics	Clothing Condition*									
	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b
Movemants										
Armpit Size	17	16	19	23	21	21	21	24	16	16
Bulk	33	15	65	36	69	55	82	70	82	77
Chest Fit	11	7	8	0	8	3	7	3	4	3
Chest Flexibility	4	0	4	5	7	9	11	13	8	9
Collar Fit	6	9	8	16	16	20	4	20	9	10
Collar Flexibility	7	0	0	3	6	8	8	9	9	12
Protruding Parts	24	24	19	31	31	24	23	25	26	21
Shoulder Fit	23	19	12	42	10	32	5	15	9	14
Shoulder Flexibility	9	9	23	33	30	31	24	28	26	25
Stability	11	4	16	5	4	3	9	8	12	7
Ventilation	8	10	9	5	3	6	3	6	9	14
Waist Fit	16	27	17	10	15	9	14	8	10	14
Waist Flexibility	8	17	24	18	32	21	34	24	43	31
Weight	8	4	24	12	26	19	40	23	32	34
Tasks										
Armpit Size	11	17	17	17	27	17	20	23	16	19
Bulk	26	19	57	37	78	54	73	73	79	74
Chest Fit	4	5	7	3	6	7	9	0	0	3
Chest Flexibility	2	9	6	1	10	7	5	11	6	4
Collar Fit	7	6	7	17	3	9	5	10	11	12
Collar Flexibility	11	3	3	4	6	12	2	7	11	9
Protruding Parts	33	23	32	36	36	24	44	33	30	29
Shoulder Fit	20	23	8	42	20	25	10	24	18	11
Shoulder Flexibility	16	17	27	50	14	33	23	21	23	18
Stability	8	2	9	3	3	4	11	4	13	11
Ventilation	11	9	7	6	6	10	13	7	8	9
Waist Fit	2	5	10	7	9	7	5	2	6	12
Waist Flexibility	0	8	6	9	8	11	14	7	14	17
Weight	8	4	29	14	22	26	33	35	35	27

Table 9

Subjects' Summed Ratings of the Importance of Each Design Characteristic in Impairing Performance for Each Clothing Condition (cont'd)

* 1a = Men's Wool
2a = Men's Wool & Men's Field
3a = Men's Wool & Men's Field/Liners
4a = Men's Wool & Men's Field/Liners & Men's Arctic
5a = Men's Wool & Men's Field/Liners & Men's Arctic/Liners

1b = Women's Wool
2b = Women's Wool & Women's Field
3b = Women's Wool & Women's Field/Liners
4b = Women's Wool & Women's Field/Liners & Men's Arctic
5b = Women's Wool & Women's Field/Liners & Men's Arctic/Liners

of the design characteristic. The mean impairment ratings for each design characteristic are presented in Table 10 and the ratings given for aiding performance are presented in Table 11. There was a tendency for the impairment ratings to increase and for ratings related to the aiding of performance to decrease as layers of clothing were added. Also, for a given number of layers, there was generally little difference between the ratings given to the men's and the women's ensembles.

With the exception of the condition in which the wool shirt and trousers were worn alone, clothing bulk received higher ratings for impairing performance than did the other design characteristics. When the arctic layer was worn with or without liners, bulk was rated as being of considerable to extreme importance in interfering with performance. For each clothing layer, the bulk rating given the women's ensemble was slightly lower than that given the men's. Shoulder flexibility was rated as moderately to considerably important in impairing performance once liners were added to the men's or the women's field layer. The rating given to protruding parts for the women's ensemble was somewhat lower than that given the men's until the arctic layer with liners was used. Here, the ratings were identical; performance was judged to be moderately to considerably impaired by the wearing of either ensemble. When all clothing layers of either ensemble were worn, waist flexibility was also rated as moderately to considerably important in impairing performance. The ratings given to weight increased as the number of clothing layers increased. When the arctic layer was worn with or without liners, this design characteristic was judged to be a moderately to considerably important source of performance interference.

Almost all of the design characteristics were rated as at least moderately important in aiding performance when the wool shirt and trousers were worn alone. These ratings decreased with the addition of clothing layers. Bulk and protruding parts received the lowest ratings of no through little importance in aiding performance when the arctic parka and trousers were worn with or without liners. The other design characteristics were judged to be of between little and moderate importance when all clothing layers were used. There were no consistent differences in the ratings as a function of ensemble type although the bulk of the men's ensemble was given a slightly more favorable rating than that of the women's for the conditions in which the wool shirt and trousers were worn alone or with field coat and trousers. For the remaining clothing conditions, the ratings given the bulk of the women's ensemble were somewhat higher than those given the men's.

The results for Question 3 of Section II (Appendix D) are presented in Table 12. Mean ratings were obtained as they had been for the two previous questions. As had occurred on Question 1 of Section II, there was a tedency for impairment ratings to increase as layers of clothing were added and there was generally little difference between the ratings given to the men's and the women's ensembles. With the exception of weight, bulk, and obstructions, no problem areas were judged as being more than between of little and moderate importance. With the addition of layers to the wool clothing, bulk

Table 10

Mean Rating of the Importance of Each Design Characteristic in Impairing Performance for Each Clothing Condition

Design Characteristic	Clothing Condition*									
	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b
Armpit Size	1.65	1.45	2.05	1.90	2.45	2.25	2.40	2.30	2.80	2.20
Bulk	2.05	1.50	3.55	2.85	3.90	3.45	4.55	4.15	4.70	4.55
Chest Fit	1.50	1.50	1.80	1.85	2.25	2.05	2.40	2.30	2.55	2.35
Chest Flexibility	1.65	1.55	2.10	1.90	2.50	2.07	2.65	2.50	2.70	2.50
Collar Fit	1.40	1.60	1.75	2.00	2.45	2.35	2.35	2.40	2.85	2.60
Collar Flexibility	1.50	1.60	1.80	1.85	2.20	2.10	2.50	2.40	2.80	2.50
Protruding Parts	2.20	1.75	2.85	2.25	3.30	2.35	3.25	2.90	3.25	3.25
Shoulder Fit	2.10	1.75	2.55	2.65	2.65	2.85	2.90	3.00	2.95	2.70
Shoulder Flexibility	2.15	1.75	2.80	2.95	3.00	3.10	3.30	3.15	3.45	3.20
Stability	1.65	1.25	2.10	1.70	2.25	2.15	2.40	2.30	2.80	2.40
Ventilation	1.55	1.55	1.85	1.65	2.05	1.90	2.65	2.05	2.80	2.35
Waist Fit	1.55	1.65	2.20	2.00	2.45	1.95	2.25	2.20	3.15	2.45
Waist Flexibility	1.60	1.70	2.60	2.15	2.85	2.50	3.25	2.60	3.80	3.00
Weight	1.50	1.45	2.55	2.00	2.70	2.25	3.30	3.30	3.70	3.35

* 1a = Men's Wool
1b = Women's Wool
2a = Men's Wool & Men's Field
2b = Women's Wool & Women's Field
3a = Men's Wool & Men's Field/Liners
3b = Women's Wool & Women's Field/Liners
4a = Men's Wool & Men's Field/Liners & Men's Arctic
4b = Women's Wool & Women's Field/Liners & Men's Arctic
5a = Men's Wool & Men's Field/Liners & Men's Arctic/Liners
5b = Women's Wool & Women's Field/Liners & Men's Arctic/Liners

Table 11

Maan Rating of tha Importance of Each Dasign Characteristic in Aiding Performance for Each Clothing Condition

Design Characteristic	Clothing Condition*									
	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b
Armpit Size	3.15	3.25	2.40	2.60	2.30	2.60	2.30	2.50	2.50	2.25
8ulk	3.10	3.40	2.30	2.10	1.80	2.15	1.80	2.05	1.55	2.00
Chest Fit	3.25	3.30	2.65	2.30	2.70	2.50	2.75	2.75	2.85	2.30
Chest Flexibility	3.60	3.50	2.85	2.40	2.70	2.55	2.70	2.65	2.90	2.35
Collar Fit	3.10	2.85	2.60	2.35	2.30	2.15	2.25	2.60	2.00	2.40
Collar Flexibility	3.20	3.00	2.75	2.40	2.45	2.15	2.35	2.33	2.20	2.30
Protruding Parts	2.80	2.80	2.05	2.35	1.70	2.45	1.85	1.70	1.85	1.80
Shoulder Fit	3.20	3.25	2.50	2.65	2.45	2.35	2.30	2.20	2.40	2.15
Shoulder Flexibility	3.60	3.40	2.65	2.20	2.40	2.50	2.35	2.15	2.55	2.20
Stability	2.90	2.80	2.10	2.10	2.25	2.30	2.35	2.30	2.05	1.90
Ventilation	3.20	2.60	2.35	2.35	2.45	2.30	2.55	2.25	2.45	2.60
Waist Fit	3.10	3.15	2.35	2.65	2.40	2.45	2.35	2.70	2.25	2.25
Waist Flexibility	3.35	3.15	2.45	2.70	2.45	2.65	2.10	2.50	2.35	2.25
Weight	3.25	3.05	2.40	2.10	2.15	2.55	2.30	2.60	2.00	2.10

* 1a = Men's Wool
1b = Women's Wool
2a = Men's Wool & Men's Field
2b = Women's Wool & Women's Field
3a = Men's Wool & Men's Field/Liners
3b = Women's Wool & Women's Field/Liners
4a = Men's Wool & Men's Field/Liners & Men's Arctic
4b = Women's Wool & Women's Field/Liners & Men's Arctic
5a = Men's Wool & Men's Field/Liners & Men's Arctic/Liners
5b = Women's Wool & Women's Field/Liners & Men's Arctic/Liners

Table 12

Mean Rating of the Importance of Problem Areas in Impairing Performance for Each Clothing Condition

Problem	Clothing Condition*									
	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b
Bulky	1.75	1.65	3.50	3.30	4.20	3.40	4.35	4.15	4.70	4.40
Chaffing	1.70	1.95	1.75	1.95	1.90	2.05	2.30	2.25	2.35	2.40
Digging In	1.30	1.55	1.75	1.75	1.85	1.95	2.10	1.95	2.05	2.25
Drafty	1.45	1.70	1.55	1.45	1.55	1.55	1.40	1.40	1.35	1.35
Heavy	1.45	1.35	2.65	2.05	2.85	2.65	3.60	3.30	3.95	3.45
Hot	1.50	1.15	1.95	1.45	1.90	1.95	2.60	2.30	2.90	2.50
Loose	2.20	2.00	2.20	1.70	1.80	1.65	1.95	2.00	2.00	1.85
Obstructions	2.05	1.80	2.90	2.25	3.00	2.30	3.60	2.90	3.15	2.95
Pressure	1.30	1.45	1.90	1.95	2.20	2.00	2.15	1.95	2.40	2.00
Pinching	1.30	1.45	1.60	1.75	1.50	1.65	1.65	1.65	1.75	1.50
Slipping	1.75	1.45	1.85	1.45	1.80	1.40	1.60	1.45	1.60	1.80
Tight	1.60	1.50	1.85	1.80	1.90	2.25	1.95	1.85	2.30	2.05
Unblanced	1.50	1.35	2.05	1.80	2.20	1.75	2.25	2.35	2.25	2.65

* 1a = Men's Wool
2a = Men's Wool & Men's Field
3a = Men's Wool & Men's Field/Liners
4a = Men's Wool & Men's Field/Liners & Men's Arctic
5a = Men's Wool & Men's Field/Liners & Men's Arctic/Liners

1b = Women's Wool
2b = Women's Wool & Women's Field
3b = Women's Wool & Women's Field/Liners
4b = Women's Wool & Women's Field/Liners & Men's Arctic
5b = Women's Wool & Women's Field/Liners & Men's Arctic/Liners

was given a higher rating than all problem areas. It was judged to be considerably to extremely important in impairing performance when all clothing was worn. The bulk ratings for the women's ensemble were slightly lower than those given the men's. Weight was judged to be moderately to considerably important in interfering with performance when the arctic clothing was introduced and again the women's ensemble was rated somewhat lower than the men's in this problem area.

Mean ratings of the adjectives presented in Section III of the questionnaire (Appendix D) were obtained by assigning a numerical value to each point on the seven-point scale. The extremely negative category was assigned a value of "1", the neutral category a value of "4", and the extremely positive category a value of "7". Each value was multiplied by the number of subjects choosing that point on the scale to obtain the mean ratings which are presented in Table 13. No mean rating was lower than the very negative category nor higher than the somewhat to very positive points on the scale.

The wool shirt and trousers were rated most favorably on every adjective and the ratings became more negative as the number of clothing layers worn increased. With the exception of the ventilation and the balance dimensions, the ratings fell to between somewhat and very negative when the arctic layer was added and decreased further when arctic liners were used. The lowest ratings given to the ventilation and the balance dimensions were between neutral and somewhat negative when all clothing layers were worn.

The men's wool shirt and trousers were rated more favorably than the women's on the comfort and the flexibility dimensions, as well as on the dimension related to the degree of liking. However, for the remaining layer conditions, the women's ensemble received more positive ratings on each adjective dimension than did the men's. For the ventilation, weight, balance, and degree of like dimensions, the women's ensemble was rated more positively when all clothing layers were worn than was the men's ensemble when no liners were worn in the arctic layer.

In general, the subjects' responses on the questionnaire indicated that bulk, weight, and degree of waist flexibility became increasingly important factors in impairing performance as clothing layers were increased. The subjects also gave the women's ensemble somewhat more favorable ratings than they gave the men's ensemble.

Clothing Fit Ratings

In the course of outfitting each participant, an experienced clothing designer determined that the best possible fit of each of the items worn in the study was achieved by following the sizing charts for the men's and the women's clothing (Appendix E). The appropriately-sized clothing items were subsequently rated by the clothing designer for acceptability of fit on each test participant. The ratings, summed over subjects, given

Table 13

Mean Rating of Bipolar Adjectives for Each Clothing Condition

Adjective Dimension	Clothing Condition* 1a	1b	2a	2b	3a	3b	4a	4b	5a	5b
Comfort	5.15	4.90	3.90	4.10	3.05	3.15	2.65	2.75	2.15	2.45
Flexibility	5.70	5.25	3.70	4.40	3.20	3.45	2.75	2.90	2.15	2.60
Ventilation	5.10	5.35	4.40	4.85	4.15	3.90	3.70	4.00	3.55	3.85
Weight	5.00	5.15	3.75	3.85	2.95	3.45	2.20	2.45	2.00	2.55
Balance	4.95	5.00	4.05	4.35	3.80	3.95	3.30	3.45	3.05	3.40
Liking	5.25	4.85	3.95	4.50	3.35	3.30	2.60	3.05	2.30	2.65

* 1a = Men's Wool
1b = Women's Wool
2a = Men's Wool & Men's Field
2b = Women's Wool & Women's Field
3a = Men's Wool & Men's Field/Liners
3b = Women's Wool & Women's Field/Liners
4a = Men's Wool & Men's Field/Liners & Men's Arctic
4b = Women's Wool & Women's Field/Liners & Men's Arctic
5a = Men's Wool & Men's Field/Liners & Men's Arctic/Liners
5b = Women's Wool & Women's Field/Liners & Men's Arctic/Liners

to some selected upper torso clothing factors are presented in Table 14 and ratings of selected lower torso factors are in Table 15. Appendix G contains all fit rating data. During the rating procedure, the item being assessed was worn over the appropriate clothing. For example, the fit of the men's field coat with liner was rated when the coat was worn over the cold weather underwear and the men's wool shirt. Garment length factors were rated by the clothing designer as being acceptable, too long, or too short, and circumference factors were rated as acceptable, too loose, or too tight.

With regard to length aspects of the men's upper torso items, the cold weather undershirt was judged acceptable on more length factors for more subjects than were the other men's items. However, the men's upper torso clothing was generally rated as being too long on the majority of test participants regardless of the particular length factor being considered. The women's wool shirt and field coat with liner were rated as acceptable with regard to length factors on the majority of test participants. The circumference factor ratings also indicated that a more acceptable fit was achieved with women's than with men's upper torso garments. In general, the men's items were rated as being too loose. However, the men's wool shirt and field coat with liner were found to be too tight on some subjects in the waist and hip areas.

The inseam and the outseam lengths of the men's lower torso clothing were judged to be acceptable on more test participants than the women's wool trousers were. Although the women's trousers were not hemmed, it was considered that an excessive amount of material would have to be cut from each leg in order to obtain a proper length. Therefore, the inseam and the outseam of the trousers were determined to be too long on the majority of the women. Among the men's items, the inseams and the outseams of the drawers were also judged to be too long in the majority of cases.

With regard to crotch length, the women's wool trousers were rated as being too long for all test participants and the arctic trousers with liner were judged as too long on nine out of the 20 subjects. The crotch lengths of the remaining clothing items had a higher rate of acceptability. The knee lengths of both the men's field trousers with liner and the arctic trousers with liner were judged to be too long on the majority of the women. In these cases, the double pleats on the trouser legs fell below the knees. The knee lengths of the men's wool trousers were also too long on nine women. The drawers and the women's wool trousers had a higher rate of acceptability. The hip and waist circumferences of all clothing items were rated as acceptable for the majority of women, although, with the exception of the drawers and the men's wool trousers, there were cases in which the trousers were rated as being too tight around the waist and the hips.

Table 14

Selected Fit Ratings for Upper Torso Clothing

Factor	Clothing	Rating: Too Long or Too Loose *n*	%	Too Short or Too Tight *n*	%	Acceptable *n*	%
Shoulder Length	Undershirt	3	15	0	0	17	85
	Men's Wool	15	75	0	0	5	25
	Women's Wool	1	5	0	0	19	95
	Men's Field/Liner	19	95	0	0	1	5
	Women's Field/Liner	0	0	0	0	20	100
	Arctic/Liner	19	95	0	0	1	5
Sleeve Length	Undershirt	15	75	0	0	5	25
	Men's Wool	19	95	0	0	1	5
	Women's Wool	6	30	0	0	13	65
	Men's Field/Liner	19	95	0	0	1	5
	Women's Field/Liner	3	15	4	20	13	65
	Arctic/Liner	17	85	0	0	3	15
Front Waist Length	Undershirt	6	30	0	0	14	70
	Men's Wool	15	75	0	0	5	25
	Women's Wool	2	10	0	0	18	90
	Men's Field/Liner	19	95	0	0	1	5
	Women's Field/Liner	1	5	0	0	19	95
	Arctic/Liner	15	75	0	0	5	25
Waist Circum	Undershirt	2	10	0	0	18	90
	Men's Wool	4	20	3	15	13	65
	Women's Wool	0	0	0	0	20	100
	Men's Field/Liner	1	5	2	10	17	85
	Women's Field/Liner	0	0	0	0	20	100
	Arctic/Liner	5	25	0	0	15	75
Hip Circum	Undershirt	1	5	0	0	19	95
	Men's Wool	1	5	5	25	14	70
	Women's Wool	0	0	0	0	20	100
	Men's Field/Liner	1	5	3	15	16	80
	Women's Field/Liner	0	0	0	0	20	100
	Arctic/Liner	2	10	0	0	18	90

Table 15

Selected Fit Ratings for Lower Torso Clothing

Factor	Clothing	Too Long or Too Loose		Too Short or Too Tight		Acceptable	
		n	%	*n*	%	*n*	%
Inseam	Drawers	12	60	0	0	8	40
	Men's Wool	7	35	0	0	13	65
	Women's Wool	15	75	0	0	5	25
	Men's Field/Liner	6	30	0	0	14	70
	Arctic/Liner	7	35	0	0	13	65
Crotch Length	Drawers	3	15	0	0	17	85
	Men's Wool	8	40	0	0	12	60
	Women's Wool	20	100	0	0	0	0
	Men's Field/Liner	6	30	0	0	14	70
	Arctic/Liner	9	45	0	0	11	55
Waist Circum	Drawers	0	0	0	0	20	100
	Men's Wool	1	5	0	0	19	95
	Women's Wool	0	0	2	10	18	90
	Men's Field/Liner	0	0	2	10	18	90
	Arctic/Liner	0	0	1	5	19	95
Hip Circum	Drawers	0	0	0	0	20	100
	Men's Wool	4	20	0	0	16	80
	Women's Wool	1	5	1	5	18	90
	Men's Field/Liner	0	0	2	10	18	90
	Arctic/Liner	0	0	2	10	18	90

DISCUSSION

The Influence of Type of Ensemble on Performance

The findings of particular interest in this study are those related to the differential effects on psychomotor performance of the men's and the women's cold weather clothing ensembles. It should be noted that all components of the men's ensemble were items designed for men, while the women's ensemble condition always consisted of at least an underlying layer of men's clothes, the cold weather undershirt and drawers. Furthermore, the number of men's items used as components of the women's ensemble increased as the number of clothing layers was increased, since only three layers of upper torso clothing and one layer of lower torso clothing designed specifically for women were available. Thus, the women's cold weather clothing ensemble, regardless of the number of layers comprising it, can be considered to be a "hybrid". In spite of this, a significant difference between the men's and the women's ensembles was obtained on four of the 14 tasks included in the performance battery and, in each instance, performance with the women's ensemble was superior to that with the men's. There were no significant interactions between clothing layers and ensembles in the analysis of the task battery data. This indicated that the relationship between the scores for the ensembles did not change appreciably as the number of layers, and thus the number of men's items used to augment the women's, was varied.

No tests in the performance battery which involved leg movements were affected by the ensemble variable. These results are not unexpected since only one layer of lower torso clothing designed for women was used, whereas three layers of women's upper torso clothing were available. Among the four tasks which were significantly affected by the type of ensemble worn were the two which involved bending at the waist in the body's sagittal plane, Standing and Sitting Trunk Flexion, and the remaining two, Upper Arm Abduction and the Pursuit Rotor, required arm movements.

Mean Standing and Sitting Trunk Flexion scores for the women's ensemble excelled those for the men's by 4.5 and 13.4%, respectively. These findings are most likely attributable to differences in the length and the proportional fit of the men's and the women's clothes which would impact upon the clothing bulk, or thickness, in the waist area. It can be seen from the finished measurements specified for the back lengths that all sizes of the women's wool shirt, field coat, and field coat liner are shorter than all sizes of the comparable men's items. In terms of fit, the front and the back waist lengths of all the men's upper torso clothes, with the exception of the cold weather undershirt, were rated as being too long on at least 70% of the subjects with the result that the waist areas of the garments fell around the subjects' hips. On the other hand, the front and the back waist lengths of the women's items were judged to be acceptable on at least 85% of the participants. Trunk Flexion required that the subject bend forward from the waist and extend both arms toward the feet in the body's sagittal plane. Arm

extension exerted an upward pull on the clothing, and the waist lines of the men's clothing sought the natural waist of the body.

Therefore, because of both length and proportional fit factors, waist flexion with the men's upper torso items entailed more material, or greater bulk, in the waist area than the comparable items designed for women did. It should be noted that smaller sizes of men's upper torso clothing could not have been used in all cases to ameliorate some of the fit problems because this would have resulted in garments which were too tight around the chest, waist, and hips.

Ensemble type also singificantly affected scores on a third flexibility task, Upper Arm Abduction. Here, the mean score for the women's ensemble was 9.0% better than that for the men's ensemble. In interpreting these results, it should be remembered that this task required the raising of both arms in the body's frontal plane. On the body itself, the arm-shoulder complex of joints is the origin of the angle generated as the arm is abducted. However, in this study, the upper torso was clothed in sleeved garments made of fabrics having limited extensibility. Therefore, the body-clothing relationship must be taken into account in assessing Upper Arm Abduction capabilities.

The principal characteristics of the garments which affected performance on this task are the lengths of the shoulders and the armhole openings. As the vertical plane of the armhole opening is moved out from the body's vertical plane, which occurs as the shoulder is lengthened, abduction at the body's arm-shoulder joint is increasingly restricted because the armhole opening, a part of the clothing's joint for abduction, then falls on the upper arm itself, instead of in the body's arm-shoulder joint area. A further consideration is the length of the armhole opening since the clothing's origin for the angle formed during Upper Arm Abduction is the lowest point of the armhole opening. As the distance between this origin and the body's origin for the formation of the angle increases, Upper Arm Abduction is decreased. To permit unrestricted arm movement in the body's frontal plane, the inner surfaces of the arm and the sleeve must remain essentially parallel to each other during arm movement. Lengthening of the armhole opening results in the formation of an acute angle between these two surfaces as the arm is abducted. If sleeve circumference and fabric extensibility are limited, the dorsal surface of the upper arm will be bound by the sleeve and arm movement will thereby be restricted.

Based upon the clothing fit ratings, it appears that the armhole openings and the shoulder lengths were indeed the factors which resulted in Upper Arm Abduction scores for the women's ensemble being significantly superior to those for the men's. The armhole openings of the men's wool shirt and field jacket were rated as being too long on at least one-half of the subjects, while the armhole opening lengths of the comparable women's items were judged to be acceptable on 95 to 100% of the subjects. That is, the garment dimensions on the women's items were such that the armhole openings extended around the arm scye, whereas the armholes of the men's garments extended down the side of the body, well below the arm scye, on more than 50% of the subjects.

With regard to the plane of the armhole opening, the clothing fit assessments revealed that the shoulder lengths of the women's upper torso clothing were acceptable on 95 to 100% of the subjects. For the comparable men's items, the shoulder lengths were such that the plane of the armhole openings was removed from the body plane on at least 75% of the participants with the result that the armhole opening fell on the upper arm itself instead of on the shoulder as the women's clothing did.

Forward and Backward Upper Arm Extension, the other two arm-shoulder flexibility tasks included in the performance battery, were not significantly affected by the type of ensemble worn. The arm movements required on both these tasks were in the body's sagittal plane. Unlike abduction of the upper arm, Forward and Backward Extension were not likely to be affected by the armhole opening characteristics of the clothing items used in this study since the arm movements required were parallel to the armhole opening plane. However, if an item had been made of a rigid or bulky material and the plane of the armhole openings had been offset from the body's plane, then reduction in arm extension capabilities may have resulted.

The fourth task in the battery which was significantly affected by the type of ensemble worn, the Pursuit Rotor, also involved movement of the arm and shoulder. The mean time on target, obtained by summing over all clothing layers, was 7.8% higher when the women's ensemble was worn than when the men's was used. Unlike the upper arm flexibility tasks, the Pursuit Rotor did not require maximum displacement of the arm from the torso. Instead, the lower arm was maintained in a horizontal position and the upper arm was abducted slightly from the torso. The greater weight of the men's clothing may have contributed more bulk to the elbow and the underarm areas thereby affecting the normal arm position for this task.

Garment sleeve length and wrist circumference are two characteristics of fit that may also have affected Pursuit Rotor performance. In rating the fit of all the garments, it was found that the sleeves of the men's items were too long on at least 75% of the women tested, while the sleeves of the women's clothing were rated as being too long on between 15 to 30% of the subjects. Wrist circumferences of the men's items were judged to be too large on 85 to 100% of the subjects. Wrist circumferences of the women's items were acceptable in 75 to 90% of the cases. Because of the combination of long sleeves and loose wrists on the men's garments, the sleeves did not terminate at the wrists, but instead extended over the hands and obscured them and most of the stylus from view. This may have interfered with the eye-hand coordination required in performing the Pursuit Rotor.

It should be noted that performance on the two manual dexterity tasks included in the battery, the Purdue Pegboard and the O'Connor Finger Dexterity Tests, was not similarly affected by the type of ensemble worn. It would seem that extension of the sleeves beyond the wrist would also impact the dexterity capabilities required in

performance of these manual tasks. However, neither of the tasks required even slight upper arm abduction and the subjects were able to retain extra sleeve material away from the hands by using the upper arms to press it against the torso.

It appears that the fit of the clothing items had a major influence on performance of the Pursuit Rotor as it did on the other three tasks which were significantly affected by the ensemble variable. The questionnaire responses of the subjects indicated that they considered differences among the ensembles in terms of bulk, waist flexibility, and weight to be important as well. The somewhat more favorable questionnaire responses given to the women's ensemble substantiate the findings regarding the superiority of this ensemble relative to the men's in terms of fit and psychomotor performance capabilities.

The Influence of Clothing Layers on Performance

A second consideration in this study was the relative effects of each of the five layers of clothing on task battery scores. With the exception of the O'Connor Finger Dexterity Test, performance of all tasks in the battery was significantly affected by this variable. In general, scores decreased as the number of clothing layers was increased. However, as was found in the Lockhart and Bensel study of cold weather clothing layers (see reference 2), the decreases were not strictly linear; the deleterious impact of some layers on performance was greater than that of others. The effects of layers also varied as a function of task type and body part involved in the task.

The flexibility tasks in the present battery can be divided into three categories on the basis of the principal body segments involved in performing the tasks. These are flexion of the upper torso at the waist, movement of the legs, and movement of the arms. Of all the tests in the battery, the two which required flexion at the waist in the body's sagittal plane were the most profoundly affected by the layer variable insofar as scores decreased significantly as each layer of clothing was added to the wool shirt and trousers. This significant performance decrement associated with each layer did not occur on the other two categories of tasks, those which required arm or leg movements. However, there was a relationship among layers which was common to all flexibility movements, with the exception of Upper Leg Backward Extension: not only the wool layer, but the field layer as well, resulted in performance levels which were significantly superior to those achieved when all clothing layers were worn. The occurrences of other significant differences among layers varied with the flexibility task being performed. Upper Leg Backward Extension was the only flexibility movement on which the scores for the wool layer did not differ significantly from those for the arctic clothing with liners, but the highest scores, those for the field layer without liners, were significantly better than those achieved when all layers were worn.

There was an additional communality among those flexibility tasks involving arm movements. On all three of these tasks, performance levels when the field layer was

worn with liners were significantly superior to performance when all layers were worn. However, the field layer with liners condition differed significantly from the arctic layer with liners condition on only one of the three leg flexibility movements. Therefore, if one were to rank the three categories of flexibility movements used in this study in terms of sensitivity to the effects of adding layers of cold weather clothing to the torso, the waist flexion tasks would be ranked first, followed by the arm-shoulder movements, with the leg-hip movements being last.

The subjects' responses to the questionnaire substantiated this ranking to some extent. The subjects rated both waist flexion tasks as being the flexibility movements most impaired by the clothing worn. The ratings given to these two tasks, as well as those given to Upper Arm Abduction, increased as the number of clothing layers was increased. Bulk and waist flexibility were also chosen by the subjects as the two design characteristics which most impaired their performances on the flexibility tasks.

In addition to the flexibility movements, performance on both psychomotor coordination tasks included in the present battery, the Pursuit Rotor and Railwalking, were significantly affected by the layer variable. Although the significant differences among layer conditions were not the same, the ordering of the scores on both of these tasks was identical. The scores worsened as the number of clothing layers was increased with one exception: performance levels for the arctic layer without liners were slightly, but not significantly, better than those for the field layer with liners. Although Railwalking scores did not vary significantly as a function of clothing layers in their study, Lockhart and Bensel also found that Pursuit Rotor scores were not ordered as a function of the number of clothing layers (see reference 2). For the men in that study, scores achieved when the field layer with liners were worn were slightly lower than those for any other condition.

As occurred on the flexibility movements, psychomotor coordination performance under both the wool and the field layer without liners conditions was significantly better than that when all clothing layers were worn. In addition, these two conditions did not differ significantly from each other on either task. The tasks varied in terms of the occurrences of other significant differences among layers as did the flexibiltiy tasks.

As was mentioned previously, the O'Connor Finger Dexterity Test was the only task in the battery which was not significantly affected by the number of clothing layers worn. However, performance on the other manual dexterity test included in this study was. As happened on the psychomotor coordination tasks, the scores were ordered as a function of the number of layers worn with one exception: performance while using the field layer with liners was slightly, but not significantly, better than performance without liners in the field layer. The wool layer and the field layer with liners yielded performance levels significantly better than those achieved when all layers were worn. There were no other significant differences among layers.

Unlike the O'Connor Test which required short, repetitive displacements of one arm and hand in the body's transverse plane, the Purdue Pegboard Test involved simultaneous movements of both hands and arms in the body's sagittal plane and parallel to the midline of the body. A different orientation of the subject's body was required for each of these tasks. It is possible that the location of the board relative to the body for the Purdue Pegboard Test was such that the sleeves increasingly obscured the board as clothing layers were added, while this was not the case on the O'Connor Test.

The remaining tasks in the battery which were significantly affected by the number of clothing layers worn were the two rate of movement tests, Front and Side Horizontal Striking. These required rapid arm and shoulder movements in the body's transverse plane and would be expected to be affected by clothing weight and bulk. On the Side Striking Task, the arm was abducted from the body and kept on the horizontal during striking out to the side and back. The effect of clothing layers on this task was similar to that on Upper Arm Abduction insofar as scores when the arctic clothing was worn with liners were significantly lower than all others and scores for the wool condition were significantly higher than all others. The Front Striking Task, like Upper Arm Forward Extension, required that the arm be raised in the body's sagittal plane. The arm was retained on the horizontal as it was moved back and forth across the body. The relationship among clothing layers obtained on the Front Striking Test was similar to that obtained on Upper Arm Forward Extension to the extent that the two extreme layer conditions did not vary significantly from all others as they did on the Side Striking and the Upper Arm Abduction Tests. Because of the similarity of the findings for the Striking Tests and these two arm flexibility movements, it may be that some garment design configurations in the arm-shoulder area which limited Upper Arm Abduction also influenced Side Horizontal Striking and those that impacted upon Upper Arm Forward Extension may also have affected Front Striking.

Although heart rate did not vary significantly as a function of the number of clothing layers worn, the subjects' responses to the questionnaire substantiate the findings on the task battery with regard to the layer variable. The particular clothing design characteristics selected by the subjects as impairing performance as layers were added were weight, bulk, and waist flexibility.

Overview

Through this study, it has been determined that certain aspects of the women's cold weather clothing, particularly fit, contribute to higher performance levels than those attained with the men's clothes on some tasks involving simple body movements. The effects of layers of cold weather clothing on performance capabilities has also been explored. In a laboratory experiment of this kind, the question arises as to the applicability of the findings to performance in military situations. This, of course, is difficult to assess. However, the tasks comprising the battery were chosen as being representative of a broad

range of basic human movements and, insofar as they were impaired by the clothing tested, it may be inferred that similar movements would also be affected, regardless of the situation. On the other hand, it should be remembered that the tasks included in the battery did not require continuous, repetitive, whole-body movements over a prolonged period of time. A further study should be considered, similar to that done by Teitlebaum and Godlman (see reference 6), in which the energy cost of wearing the men's cold weather ensemble vs. the women's is assessed during prolonged walking or running.

CONCLUSIONS

The major findings of this study, based upon the overall results, are as follows:

1. The men's ensemble impaired certain aspects of psychomotor performance, particularly body flexibility, to a greater extent than the women's ensemble did. This difference is attributable to the more precise fit of the women's clothing.

2. On those tasks in which performance levels differed significantly as a function of the type of ensemble, scores were from 4 to 13% better when the women's ensemble was worn. The particular fit characteristics of the men's garment which impaired task performance were: excessive front and back waist lengths, shoulder lengths, armhole opening lengths, sleeve lengths, and wrist circumferences.

3. There were no significant interactions in the analysis of the task battery data. This indicates that the relationship between the scores for the men's and the women's ensembles did not change appreciably as the number of clothing layers, and thus the number of men's items used to augment the women's, was varied.

4. Psychomotor performance level and user acceptance decreased as the number of clothing layers worn was increased. However, the layers were not equally deleterious in their effects on performance nor were all aspects of performance equally impaired by wearing a certain combination of layers.

5. The women's ensemble was rated more favorably than the men's by the test participants, particularly with regard to the relative bulk, waist flexibility, and weight of these two ensembles.

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APPENDIX A

Photographs of Clothing Conditions

Figure A1a. Men's wool, cold weather shirt and trousers.

Figure A1b. Women's wool, cold weather shirt and trousers.

Figure A2a. Men's field coat and trousers worn over the men's wool shirt and trousers.

Figure A2b. Women's field coat and men's field trousers worn over the women's wool shirt and trousers.

Figure A3a. Men's field coat and trousers with liners worn over the men's wool shirt and trousers.

Figure A3b. Women's field coat with liner and men's field trousers with liner worn over the women's wool shirt and trousers.

Figure A4a. Men's parka and arctic trousers worn over the men's wool shirt and trousers and the men's field coat and trousers with liners.

Figure A4b. Men's parka and arctic trousers worn over the women's wool shirt and trousers, the women's field coat with liner, and the men's field trousers with liner.

Figure A5a. Men's parka and arctic trousers with liners worn over the men's wool shirt and trousers and the men's field coat and trousers with liners.

Figure A5b. Men's parka and arctic trousers with liners worn over the women's wool shirt and trousers, the women's field coat with liner, and the men's field trousers with liner.

APPENDIX B

Finished Measurements

of

Cold Weather Clothing Items

Appendix B1

Finished Measurements (cm) for Upper Torso Clothing

Measurement	Size		Clothing Item: Wool	Field	Field Liner	Arctic	Arctic Liner
Half Chest/Bust[1]	**Men's**						
	X–Sm	Short	—	52.7	—	—	—
		Reg	45.7	52.7	56.5	63.5	63.5
		Long	—	52.7	—	—	—
	Sm	Short	—	57.8	—	—	—
		Reg	50.8	57.8	61.6	68.6	68.6
		Long	—	57.8	—	—	—
	Med	Short	—	62.9	—	—	—
		Reg	55.9	62.9	66.7	73.7	73.7
		Long	—	62.9	—	—	—
	Lge	Short	—	67.9	—	—	—
		Reg	61.0	67.9	71.8	78.7	78.7
		Long	—	67.9	—	—	—
	X–Lge	Short	—	73.0	—	—	—
		Reg	66.0	73.0	76.8	83.8	83.8
		Long	—	73.0	—	—	—
	Tolerance		±1.3	±1.9	±1.9	±1.9	±1.9
	Women's						
	8	Reg	47.6	53.3	53.7	—	—
	10	Reg	49.5	55.2	55.6	—	—
	12	Reg	51.4	57.2	57.5	—	—
		Long	—	57.2	—	—	—
	14	Reg	53.3	59.7	59.4	—	—
		Long	—	59.7	—	—	—
	16	Reg	55.2	61.0	61.6	—	—
		Long	—	61.0	—	—	—
	18	Reg	57.8	63.5	64.0	—	—
		Long	—	63.5	—	—	—
	20	Reg	60.3	66.0	64.0	—	—
	Tolerance		±1.3	±1.9	±1.3	—	—

Appendix B1

Finished Measurements (cm) for Upper Torso Clothing (cont'd)

Measurement	Size		Clothing Item: Wool	Field	Field Liner	Arctic	Arctic Liner
Back Length[2]	Men's						
		Short	—	74.9	—	—	—
	X–Sm	Reg	73.7	78.7	69.8	104.1	82.6
		Long	—	82.6	—	—	—
		Short	—	76.2	—	—	—
	Sm	Reg	74.9	80.0	71.1	105.4	83.8
		Long	—	83.8	—	—	—
		Short	—	77.5	—	—	—
	Med	Reg	76.2	81.3	72.4	106.7	85.1
		Long	—	85.1	—	—	—
		Short	—	78.7	—	—	—
	Lge	Reg	77.5	82.6	73.7	108.0	86.4
		Long	—	86.4	—	—	—
		Short	—	80.0	—	—	—
	X–Lge	Reg	78.7	83.8	74.9	109.2	87.6
		Long	—	87.6	—	—	—
	Tolerance		±1.9	±2.5	±1.3	±2.5	±1.9
	Women's						
	8	Reg	62.2	67.3	62.2	—	—
	10	Reg	62.9	68.0	62.9	—	—
	12	Reg	63.5	68.0	63.5	—	—
		Long	—	75.6	—	—	—
	14	Reg	64.1	68.0	64.1	—	—
		Long	—	75.6	—	—	—
	16	Reg	64.8	68.3	64.8	—	—
		Long	—	75.9	—	—	—
	18	Reg	65.4	69.2	65.4	—	—
		Long	—	76.8	—	—	—
	20	Reg	66.0	71.4	66.0	—	—
	Tolerance		±1.3	±1.9	+1.9,–1.3	—	—

Appendix B1

Finished Measurements (cm) for Upper Torso Clothing (cont'd)

Measurement	Size		Clothing Item: Wool	Field	Field Liner	Arctic	Arctic Liner
Sleeve Length[3]	Men's						
		Short	—	46.4	—	—	—
	X–Sm	Reg	86.4	48.9	55.9	63.5	59.7
		Long	—	51.4	—	—	—
		Short	—	46.4	—	—	—
	Sm	Reg	88.9	48.9	56.5	64.8	61.0
		Long	—	51.4	—	—	—
		Short	—	46.4	—	—	—
	Med	Reg	91.4	48.9	57.2	66.0	62.2
		Long	—	51.4	—	—	—
		Short	—	46.4	—	—	—
	Lge	Reg	94.0	48.9	57.8	67.3	63.5
		Long	—	51.4	—	—	—
		Short	—	46.4	—	—	—
	X–Lge	Reg	96.5	48.9	58.4	68.6	64.8
		Long	—	51.4	—	—	—
	Tolerance		±1.9	±1.9	±1.3	±1.9	±1.9
	Women's						
	8	Reg	59.7	49.5	52.1	—	—
	10	Reg	60.3	50.8	52.7	—	—
	12	Reg	61.0	52.1	53.3	—	—
		Long	—	58.4	—	—	—
	14	Reg	61.6	53.3	54.0	—	—
		Long	—	58.4	—	—	—
	16	Reg	62.2	54.0	54.6	—	—
		Long	—	58.4	—	—	—
	18	Reg	62.9	54.6	55.2	—	—
		Long	—	59.7	—	—	—
	20	Reg	63.5	56.5	55.9	—	—
	Tolerance		±1.3	±1.3	± .6	—	—

Appendix B1

Finished Measurements (cm) for Upper Torso Clothing (cont'd)

[1] This measurement is taken at the base of the armhole from folded edge to folded edge with the front closed or, in the case of the men's liners, with the front edges abutting.

[2] This measurement is taken along the center of the back from the undercollar seam or, in the case of the liners, from the edge of the neck to the botton edge of the garment.

[3] For the men's wool shirt, this is measured from the center back at the collar seam, diagonally across the back, and down the sleeve to the bottom. For the men's and the women's field jackets, this measurement extends from the base of the armhole, along the inseam to the bottom of the sleeve. For the remaining items, it is taken from the top to the bottom of the sleeve.

Appendix B2

Finished Measurements (cm) of Lower Torso Clothing

Measurement	Size		Clothing Item				
			Wool	Field	Field Liners	Arctic	Arctic Liners
Half Waist[1]	Men's						
		Short	35.7	36.8	42.5	40.6	47.0
	X–Sm	Reg	35.7	36.8	42.5	40.6	47.0
		Long	35.7	36.8	42.5	40.6	47.0
		Short	40.9	41.9	47.6	45.7	52.1
	Sm	Reg	40.9	41.9	47.6	45.7	52.1
		Long	40.9	41.9	47.6	45.7	52.1
		Short	45.9	47.0	52.7	50.8	57.2
	Med	Reg	45.9	47.0	52.7	50.8	57.2
		Long	45.9	47.0	52.7	50.8	57.2
		Short	51.1	52.1	57.8	55.9	62.2
	Lge	Reg	51.1	52.1	57.8	55.9	62.2
		Long	51.1	52.1	57.8	55.9	62.2
		Short	56.2	57.2	62.9	61.0	67.3
	X–Lge	Reg	56.2	57.2	62.9	61.0	67.3
		Long	56.2	57.2	62.9	61.0	67.3
	Tolerance		+1.3,-.6	+1.9,-1.3	+1.9,-1.3	± 1.3	+2.5,-1.3
	Women's						
	8	Reg	29.8	—	—	—	—
	10	Reg	31.8	—	—	—	—
	12	Reg	33.7	—	—	—	—
	14	Reg	35.6	—	—	—	—
	16	Reg	37.5	—	—	—	—
	18	Reg	40.0	—	—	—	—
	20	Reg	42.6	—	—	—	—
	Tolerance		±1.3	—	—	—	—

Appendix B2

Finished Measurements (cm) of Lower Torso Clothing (cont'd)

Measurement	Size	Wool	Field	Field Liner	Arctic	Arctic Liner
			Clothing Item			
Half Hip[2]	Women's					
	8 Reg	47.0	—	—	—	—
	10 Reg	48.9	—	—	—	—
	12 Reg	50.8	—	—	—	—
	14 Reg	52.7	—	—	—	—
	16 Reg	54.6	—	—	—	—
	18 Reg	56.5	—	—	—	—
	20 Reg	59.1	—	—	—	—
	Tolerance	±1.3	—	—	—	—
Inseam[3]	Men's					
	Short	71.1	67.3	55.9	64.8	58.4
	X–Sm Reg	78.7	74.9	55.9	72.4	58.4
	Long	86.4	82.6	66.0	80.0	69.2
	Short	71.1	67.6	55.9	64.8	58.4
	Sm Reg	78.7	75.3	55.9	72.4	58.4
	Long	86.4	82.9	66.0	80.0	69.2
	Short	71.1	67.9	55.9	64.8	58.4
	Med Reg	78.7	75.6	55.9	72.4	58.4
	Long	86.4	83.2	66.0	80.0	69.2
	Short	71.1	68.3	55.9	64.8	58.4
	Lge Reg	78.7	75.9	55.9	72.4	58.4
	Long	86.4	83.5	66.0	80.0	69.2
	Short	71.1	68.6	55.9	64.8	58.4
	X–Lge Reg	78.7	76.2	55.9	72.4	58.4
	Long	86.4	83.8	66.0	80.0	69.2
	Tolerance	+1.9,-1.3	±1.9	±1.9	±1.9	±2.5

Appendix B2

Finished Measurements (cm) of Lower Torso Clothing (cont'd)

Measurement	Size		Clothing Item: Wool	Field	Field Liners	Arctic	Arctic Liners
Outseam[4]	Men's						
		Short	99.1	95.2	—	94.0	—
	X–Sm	Reg	108.3	104.1	—	102.9	—
		Long	117.5	113.0	—	111.8	—
		Short	100.3	96.5	—	95.2	—
	Sm	Reg	109.6	105.4	—	104.1	—
		Long	118.7	114.3	—	113.0	—
		Short	101.6	97.8	—	96.5	—
	Med	Reg	110.8	106.7	—	105.4	—
		Long	120.0	115.6	—	114.3	—
		Short	102.9	99.1	—	97.8	—
	Lge	Reg	112.1	108.0	—	106.7	—
		Long	121.3	116.8	—	115.6	—
		Short	104.1	100.3	—	99.1	—
	X–Lge	Reg	113.4	109.2	—	108.0	—
		Long	122.6	118.1	—	116.8	—
	Tolerance		+1.9,–1.3	±1.9	—	±1.9	—
	Women's						
	8	Reg	114.3	—	—	—	—
	10	Reg	116.8	—	—	—	—
	12	Reg	118.1	—	—	—	—
	14	Reg	119.4	—	—	—	—
	16	Reg	120.0	—	—	—	—
	18	Reg	120.6	—	—	—	—
	20	Reg	121.3	—	—	—	—
	Tolerance		±1.3	—	—	—	—

Appendix B2

Finished Measurements (cm) of Lower Torso Clothing (cont'd)

Measurement	Size		Clothing Item: Wool	Field	Field Liners	Arctic	Arctic Liners
Half Knee[5]	Men's						
		Short	26.0	29.8	—	35.3	—
	X–Sm	Reg	26.0	29.8	—	35.3	—
		Long	26.0	29.8	—	35.3	—
		Short	27.3	31.1	—	36.8	—
	Sm	Reg	27.3	31.1	—	36.8	—
		Long	27.3	31.1	—	36.8	—
		Short	28.6	32.4	—	38.7	—
	Med	Reg	28.6	32.4	—	38.7	—
		Long	28.6	32.4	—	38.7	—
		Short	29.8	33.7	—	40.6	—
	Lge	Reg	29.8	33.7	—	40.6	—
		Long	29.8	33.7	—	40.6	—
		Short	31.1	35.3	—	42.2	—
	X–Lge	Reg	31.1	35.3	—	42.2	—
		Long	31.1	35.3	—	42.2	—
	Tolerance		±.6	±1.3	—	±1.3	—
Half Bottom[6]	Men's						
		Short	22.9	26.4	—	30.5	—
	X–Sm	Reg	22.9	26.4	—	30.5	—
		Long	22.9	26.4	—	30.5	—
		Short	23.5	27.0	—	31.1	—
	Sm	Reg	23.5	27.0	—	31.1	—
		Long	23.5	27.0	—	31.1	—
		Short	24.1	27.6	—	31.8	—
	Med	Reg	24.1	27.6	—	31.8	—
		Long	24.1	27.6	—	31.8	—
		Short	24.8	28.3	—	32.4	—
	Large	Reg	24.8	28.3	—	32.4	—
		Long	24.8	28.3	—	32.4	—

Appendix B2

Finished Measurements (cm) of Lower Torso Clothing (cont'd)

Measurement	Size	Clothing Item: Wool	Field	Field Liners	Arctic	Arctic Liners
Half Bottom[6] (cont'd)	Men's					
	Short	25.4	28.9	—	33.0	—
	X–Lge Reg	25.4	28.9	—	33.0	—
	Long	25.4	28.9	—	33.0	—
	Tolerance	± .6	±.6	—	± .6	—

[1] For the women's wool trousers, this measurement is taken across the center of the waist with the trousers folded in half at the front and side seams. For the remaining items, it is taken along the top of the waist from side folded edge to side folded edge with the trousers buttoned and flat.

[2] This measurement is taken from side folded edge to side folded edge 222 mm below the bottom edge of the waistband.

[3] This measurement is taken from the center of the crotch seam to the bottom of the trouser leg.

[4] This measurement is taken from the waist to the bottom of the trouser leg.

[5] This measurement is taken from folded edge to folded edge.

[6] This measurement is taken from folded edge to folded edge at the bottom of the trouser leg.

APPENDIX C

Descriptions of Clothing Components

The cold weather underwear is wool and cotton knit. The undershirt is hip length with long sleeves and rib-knit wristlets. It has a high, round neckline with a two-button closure. The drawers are ankle length with rib-knit anklets, a fly-front closure, and an elasticized waistband with suspender loops attached at each side of the front.

The men's wool serge trousers are conventionally-styled and of an 18 oz/yd^2 fabric. These cold weather trousers have two side pockets, two hip pockets with flap closures, belt loops, and a slide-fastened fly closure. Slide buckles on each side of the trousers are used to adjust the waistband, and suspender loops are provided on each side of the front waistband. The women's wool serge trousers are made of the same 18 oz/yd^2 fabric as the men's wool trousers are. They have a combination slant pocket and two-button placket located on each side. There is also a three-button closure on each side of the waistband for size adjustment. The trousers are unhemmed to allow for individual length adjustment. Unlike the men's wool trousers, there are no belt or suspender loops on the women's trousers. The men's cold weather shirt is made of a 16 oz/yd^2 wool and nylon flannel fabric. It is coat-styled with a six-button front closure and one-button cuff closures. There are two patch pockets with button-flap closures on each side of the upper front. The women's shirt is made of a 10.5 oz/yd^2 wool and nylon flannel. It is also coat-styled with a straight bottom and side vents. It has a front-button closure, convertible collar, double back yoke, full-length sleeves with one-button cuffs, and two patch pockets with flap and button closures. The suspenders, which are worn over the wool shirt, are a scissors-back type made of cotton elastic. They have front hooks for lower garment suspension and slide buckles for size adjustment.

The field trousers are made of 50% nylon and 50% cotton, 8.5 to 9.0 oz/yd^2 sateen. They have a slide-fastened fly closure, belt loops, and slide-buckle waist adjustment straps. There is a front pocket with snap-fastened flap closures on each thigh, hip pockets with flaps, and cargo pockets. The knee is double pleated and drawcords are located at the ends of the trouser legs. Loops on each side of the front waistband are used to attach suspenders and button tabs are located on the inside waistband for attaching a field trouser liner. The field trouser liner is a quilted, three-ply garment made of rip-stop, nylon-covered, polyester batting which weighs approximately 5.0 oz/yd^2. The liner is three-quarter length with a single button front closure on the waistband and double pleats at the knees. The waistband has six vertical buttonholes for attaching the liner to the field trousers.

The men's, hip-length field coat is made of the same 8.5 to 9.0 oz/yd^2 cotton and nylon sateen material as the field trousers. The coat has a slide-fastened fly front closure with a snap-fastener. The set-in sleeves have wrist tabs that can be adjusted and hand extension shields. The bellows-type breast pockets with snap-fastened flap closures are located on each side of the upper front and inside hanging pockets with snap-fastened flap closures are located on each side of the lower front. The coat has waist and hem

drawcords, a full cotton oxford cloth lining, and buttons placed along the inside facing of the front closure for attaching the field coat liner. The men's field coat liner has buttonholes at the neck and front edges and buttonhole tabs at the sleeve bottoms for the purpose of attaching the liner to the field coat. The liner is a quilted, three-ply garment made of rip-stop, nylon-covered, polyester batting weighing approximately 5.0 oz/yd^2. It is collarless and of hip-length cardigan style with openings under the armholes.

The women's field coat is made of the same 8.5 to 9.0 oz/yd^2, cotton and nylon sateen material as is used in the men's field coat. It is single-breasted with a convertible collar, front button closure, set-in sleeves, a drawcord at the waist, and a full lining made of cotton oxford cloth. Inside hanging pockets are located on the lower left and right front of the jacket. The women's field coat liner is made of the 16.0 oz/yd^2 wool and nylon flannel which is also used in the men's wool shirt. It is single-breasted with set-in sleeves, knitted collar and cuffs, and a front-button closure. Patch pockets are located on the lower left and right front, and the half lining is made of nylon oxford cloth.

The arctic trousers are made of cotton and nylon oxford cloth which weighs 4.8 to 5.8 oz/yd^2. They have a slide-fastened fly closure, drawcords at the waist and at the ends of the trouser legs, and cargo pockets. The knees are double-pleated. Loops on each side of the front waistband are used to attach suspenders and the trouser liner is attached to button tabs on the inside of the waistband. The arctic trouser liner has a single-button front closure and an opening on each side of access to undergarment pockets. The liner is made of the same nylon, quilted batting used for the men's field coat and trouser liners.

The parka is made of the same cotton and nylon oxford cloth material used in the arctic trousers. It is single-breasted and has a slide-fastened front closure with a snap-fastened protective flap. The sleeves have a single-button closure. A slit-type breast pocket with a flap and a snap-fastener flap closure is located on each side of the front. The parka has waist and hemline drawcords and inside buttons and button tabs for attaching the liner. The liner is collarless and a three-quarter length cardigan style. The parka liner is made of the nylon, quilted batting. Buttonholes along the neck and front edges and button tabs on the sleeve are used for attaching the liner to the parka.

APPENDIX D

Clothing and Personal Equipment Performance Questionnaire

CLOTHING AND PERSONAL EQUIPMENT PERFORMANCE QUESTIONNAIRE

Name: _____ Clothing Condition: _____

Section I. Task Performance.

1. Using ranks 1, 2, and 3, rank the three tasks and the three movements most impaired under the present experimental conditions.

Movements		Psychomotor Tasks	
Standing trunk flexion	____	Pursuit rotor	____
Sitting trunk flexion	____	Railwalk	____
Upper arm, abduction	____	O'Connor Finger Dexterity	____
Upper arm, forward extension	____	Purdue Pegboard assembly	____
Upper arm, backward extension	____	Upper arm horizontal striking, front	____
Upper leg, abduction	____	Upper arm horizontal striking, side	____
Upper leg, forward extension	____		
Upper leg, backward extension	____		

2. Choose the five design characteristics which were most important to you in impairing task performance or interfering with your movements. Assign ranks from 1 through 5 to the first through the fifth most important source of interference. Do this for both tasks and movements.

Most Important Characteristic

	Movements	Tasks
Armpit size	____	____
Bulk	____	____
Chest fit	____	____
Chest flexibility	____	____
Collar fit	____	____
Collar flexibility	____	____
Protruding parts	____	____
Shoulder fit	____	____
Shoulder flexibility	____	____
Stability	____	____
Ventilation	____	____
Waist fit	____	____
Waist flexibility	____	____
Weight	____	____

Section II. Importance of Design Characteristics

1. Rate each of the characteristics listed below to show how important they were to you in interfering with the tasks and movements.

	OF NO IMPORTANCE	OF LITTLE IMPORTANCE	OF MODERATE IMPORTANCE	OF CONSIDERABLE IMPORTANCE	OF EXTREME IMPORTANCE
a. Armpit size					
b. Bulk					
c. Chest fit					
d. Chest flexibility					
e. Collar fit					
f. Collar flexibility					
g. Protruding parts					
h. Shoulder fit					
i. Shoulder flexibility					
j. Stability					
k. Ventilation					
l. Waist fit					
m. Waist flexibility					
n. Weight					

Comments: (additional characteristics, etc.)

2. Rate each of the characteristics listed below to show how important they were in helping you to do well on the tasks and movements.

	OF NO IMPORTANCE	OF LITTLE IMPORTANCE	OF MODERATE IMPORTANCE	OF CONSIDERABLE IMPORTANCE	OF EXTREME IMPORTANCE
a. Armpit size					
b. Bulk					
c. Chest fit					
d. Chest flexibility					
e. Collar fit					
f. Collar flexibility					
g. Protruding parts					
h. Shoulder fit					
i. Shoulder flexibility					
j. Stability					
k. Ventilation					
l. Waist fit					
m. Waist flexibility					
n. Weight					

Comments: (additional characteristics, etc.)

3. Rate each of the problems listed below to show how important they were to you in interfering with your performance.

	OF NO IMPORTANCE	OF LITTLE IMPORTANCE	OF MODERATE IMPORTANCE	OF CONSIDERABLE IMPORTANCE	OF EXTREME IMPORTANCE
a. Bulky					
b. Chaffing					
c. Digging in					
d. Drafty					
e. Heavy					
f. Hot					
g. Loose					
h. Obstructions					
i. Pressure					
j. Pinching					
k. Slipping					
l. Tight					
m. Unbalanced					

(Comments: (additional problems, etc.)

Section III. Preference.

Indicate your opinion, whether neutral, positive, or negative, on each of the following dimensions. Circle the appropriate vertical line.

While performing the tasks, I found the clothing and personal equipment to be:

extremely	very	somewhat	neutral	somewhat	very	extremely
−3	−2	−1	0	+1	+2	+3

1. uncomfortable — comfortable

2. inflexible — flexible

3. poorly ventilated — well ventilated

4. heavy — light

5. poorly balanced — well balanced

In general, my attitude toward the clothing and personal equipment was:

6. dislike — like

APPENDIX E

Sizing Charts for Cold Weather Clothing

Appendix E1

Sizing Chart for Women's Cold Weather Clothing

Size	Body Measurement			
	Bust Circum (in)	Waist Circum (in)	Hip Circum (in)	Height (in)
8 Reg	30½ – 32	22½ – 24	33 – 35	
10 Reg	32 – 33½	23½ – 25	34½ – 36½	
12 Reg	33½ – 35	25 – 26½	36 – 38	63–67
Long				>67
14 Reg	35 – 36½	26½ – 28	37½ – 39½	63–67
Long				>67
16 Reg	36½ – 38	28 – 29½	39 – 41	63–67
Long				>67
18 Reg	38 – 39½	30 – 31½	40½ – 42½	63–67
Long				>67
20 Reg	40 – 41½	32 – 33½	43 – 44½	

Appendix E2

Sizing Chart for Men's Cold Weather Clothing

Size		Body Measurement: Chest Circum (in)	Waist Circum (in)	Height (in)	Inseam (in)
X-Sm	Short	<33	<27	<67	<31½
	Reg	<33	<27	67–71	29½ – 32½
	Long	<33	<27	>71	>32½
Sm	Short	33–37	27–31	<67	<31½
	Reg	33–37	27–31	67–71	29½ – 32½
	Long	33–37	27–31	>71	>32½
Med	Short	37–41	31–35	<67	<31½
	Reg	37–41	31–35	67–71	29½ – 32½
	Long	37–41	31–35	>71	>32½
Lge	Short	41–45	35–39	<67	<31½
	Reg	41–45	35–39	67–71	29½ –32½
	Long	41–45	35–39	>71	>32½
X-Lge	Short	>45	>39	<67	<31½
	Reg	>45	>39	67–71	29½ – 32½
	Long	>45	>39	>71	>32½

APPENDIX F

Fit Rating Form

Subject #_____ Name:_____

CLOTHING ITEM	LENGTH FACTORS	TOO LONG	TOO SHORT	ACCEPT.	CIRCUM. FACTORS	TOO LOOSE	TOO TIGHT	ACCEPT.
Men's Undershirt	Shoulder Lgth. Sleeve Lgth. Front Waist Lgth. Back Waist Lgth. Length Armhole				Wrist Circum. Neck Circum. Chest Circum. Waist Circum. Hip Circum. Cross Back			
Men's Drawers	Inseam Outseam Crotch Lgth. Knee Lgth.				Waist Circum. Hip Circum.			
Men's Wool Shirt	Shoulder Lgth. Sleeve Lgth. Front Waist Lgth. Back Waist Lgth. Length Armhole				Wrist Circum. Neck Circum. Chest Circum. Waist Circum. Hip Circum. Cross Back			
Men's Wool Trousers	Inseam Outseam Crotch Lgth. Knee Lgth.				Waist Circum. Hip Circum.			
Men's Field Jacket/ A Lnr.	Shoulder Lgth. Sleeve Lgth. Front Waist Lgth. Back Waist Lgth. Length Armhole				Wrist Circum. Neck Circum. Chest Circum. Waist Circum. Hip Circum. Cross Back			

Subject #_____ Name:_____

CLOTHING ITEMS	LENGTH FACTORS	TOO LONG	TOO SHORT	ACCEPT.	CIRCUM. FACTORS	TOO LOOSE	TOO TIGHT	ACCEPT.
Men's Field Trousers/ A Lnr.	Inseam Outseam Crotch Lgth. Knee Lgth.				Waist Circum. Hip Circum.			
Men's Parka/ A Lnr.	Shoulder Lgth. Sleeve Lgth. Front Waist Lgth. Back Waist Lgth. Length Armhole				Wrist Circum. Neck Circum. Chest Circum. Waist Circum. Hip Circum. Cross Back			
Men's Arctic Trousers/ A Lnr.	Inseam Outseam Crotch Lgth. Knee Lgth.				Waist Circum. Hip Circum.			
Women's Flannel Shirt	Shoulder Lgth. Sleeve Lgth. Front Waist Lgth. Back Waist Lgth. Length Armhole				Wrist Circum. Neck Circum. Chest Circum. Waist Circum. Hip Circum. Cross Back			
Women's Serge Slacks	Inseam Outseam Crotch Lgth. Knee Lgth.				Waist Circum. Hip Circum.			

Subject #_____ Name:_____

CLOTHING ITEMS	LENGTH FACTORS	TOO LONG	TOO SHORT	ACCEPT.	CIRCUM. FACTORS	TOO LOOSE	TOO TIGHT	ACCEPT.
Women's Field Liner	Shoulder Lgth.				Wrist Circum.			
	Sleeve Lgth.				Neck Circum.			
	Front Waist Lgth.				Chest Circum.			
	Back Waist Lgth.				Waist Circum.			
	Length				Hip Circum.			
	Armhole				Cross Back			
Women's Field Jacket/Lnr.	Shoulder Lgth.				Wrist Circum.			
	Sleeve Lgth.				Neck Circum.			
	Front Waist Lgth.				Chest Circum.			
	Back Waist Lgth.				Waist Circum.			
	Length				Hip Circum.			
	Armhole				Cross Back			

APPENDIX G

Fit Ratings for Clothing Items

Appendix G1

Fit Ratings for Upper Torso Clothing

Factor	Clothing	Rating: Too Long or Too Loose *n*	%	Rating: Too Short or Too Tight *n*	%	Acceptable *n*	%
Shoulder Length	Undershirt	3	15	0	0	17	85
	Men's Wool	15	75	0	0	5	25
	Women's Wool	1	5	0	0	19	95
	Men's Field/Liner	19	95	0	0	1	5
	Women's Field/Liner	0	0	0	0	20	100
	Arctic/Liner	19	95	0	0	1	5
Sleeve Length	Undershirt	15	75	0	0	5	25
	Men's Wool	19	95	0	0	1	5
	Women's Wool	6	30	1	5	13	65
	Men's Field/Liner	19	95	0	0	1	5
	Women's Field/Liner	3	15	4	20	13	65
	Arctic/Liner	17	85	0	0	3	15
Front Waist Length	Undershirt	6	30	0	0	14	70
	Men's Wool	15	75	0	0	5	25
	Women's Wool	2	10	0	0	18	90
	Men's Field/Liner	19	95	0	0	1	5
	Women's Field/Liner	1	5	0	0	19	95
	Arctic/Liner	15	75	0	0	5	25
Back Waist Length	Undershirt	6	30	0	0	14	70
	Men's Wool	20	100	0	0	0	0
	Women's Wool	3	15	0	0	17	85
	Men's Field/Liner	14	70	0	0	6	30
	Women's Field/Liner	1	5	0	0	19	95
	Arctic/Liner	17	85	0	0	3	15
Total Length	Undershirt	15	75	0	0	5	25
	Men's Wool	13	65	0	0	7	35
	Women's Wool	1	5	0	0	19	95
	Men's Field/Liner	14	70	0	0	6	30
	Women's Field/Liner	1	5	1	5	18	90
	Arctic/Liner	16	80	0	0	4	20
Armhole Length	Undershirt	2	10	0	0	18	90
	Men's Wool	17	85	0	0	3	15
	Women's Wool	1	5	0	0	19	95
	Men's Field/Liner	10	50	0	0	10	50
	Women's Field/Liner	0	0	0	0	20	100
	Arctic/Liner	13	65	0	0	7	35

Appendix G1

Fit Ratings for Upper Torso Clothing (cont'd)

Factor	Clothing	Rating: Too Long or Too Loose		Too Short or Too Tight		Acceptable	
		n	%	*n*	%	*n*	%
Wrist Circum	Undershirt	20	100	0	0	0	0
	Men's Wool	20	100	0	0	0	0
	Women's Wool	5	25	0	0	15	75
	Men's Field/Liner	20	100	0	0	0	0
	Women's Field/Liner	2	10	0	0	18	90
	Arctic/Liner	17	85	0	0	3	15
Neck Circum	Undershirt	10	50	0	0	10	50
	Men's Wool	16	80	0	0	4	20
	Women's Wool	0	0	0	0	20	100
	Men's Field/Liner	14	70	1	5	5	25
	Women's Field/Liner	0	0	5	25	15	75
	Arctic/Liner	15	75	0	0	5	25
Chest Circum	Undershirt	2	10	0	0	18	90
	Men's Wool	4	20	0	0	16	80
	Women's Wool	0	0	0	0	20	100
	Men's Field/Liner	1	5	0	0	19	95
	Women's Field/Liner	0	0	0	0	20	100
	Arctic/Liner	6	30	0	0	14	70
Waist Circum	Undershirt	2	10	0	0	18	90
	Men's Wool	4	20	3	15	13	65
	Women's Wool	0	0	0	0	20	100
	Men's Field/Liner	1	5	2	10	17	85
	Women's Field/Liner	0	0	0	0	20	100
	Arctic/Liner	5	25	0	0	15	75
Hip Circum	Undershirt	1	5	0	0	19	95
	Men's Wool	1	5	5	25	14	70
	Women's Wool	0	0	0	0	20	100
	Men's Field/Liner	1	5	3	15	16	80
	Women's Field/Liner	0	0	0	0	20	100
	Arctic/Liner	2	10	0	0	18	90
Cross Back	Undershirt	8	40	0	0	12	60
	Men's Wool	19	95	0	0	1	5
	Women's Wool	1	5	1	5	18	90
	Men's Field/Liner	17	85	0	0	3	15
	Women's Field/Liner	0	0	0	0	20	100
	Arctic/Liner	18	90	0	0	2	10

Appendix G2

Fit Ratings for Lower Torso Clothing

Factor	Clothing	Rating: Too Long or Too Loose *n*	%	Too Short or Too Tight *n*	%	Acceptable *n*	%
Inseam	Drawers	12	60	0	0	8	40
	Men's Wool	7	35	0	0	13	65
	Women's Wool	15	75	0	0	5	25
	Men's Field/Liner	6	30	0	0	14	70
	Arctic/Liner	7	35	0	0	13	65
Outseam	Drawers	12	60	0	0	8	40
	Men's Wool	7	35	0	0	13	65
	Women's Wool	15	75	0	0	5	25
	Men's Field/Liner	6	30	0	0	14	70
	Arctic/Liner	7	35	0	0	13	65
Crotch Length	Drawers	3	15	0	0	17	85
	Men's Wool	8	40	0	0	12	60
	Women's Wool	20	100	0	0	0	0
	Men's Field/Liner	6	30	0	0	14	70
	Arctic/Liner	9	45	0	0	11	55
Knee Length	Drawers	7	35	0	0	13	65
	Men's Wool	9	45	0	0	11	55
	Women's Wool	6	30	0	0	14	70
	Men's Field/Liner	13	65	0	0	7	35
	Arctic/Liner	16	80	0	0	4	20
Waist Circum	Drawers	0	0	0	0	20	100
	Men's Wool	1	5	0	0	19	95
	Women's Wool	0	0	2	10	18	90
	Men's Field/Liner	0	0	2	10	18	90
	Arctic/Liner	0	0	1	5	19	95
Hip Circum	Drawers	0	0	0	0	20	100
	Men's Wool	4	20	0	0	16	80
	Women's Wool	1	5	1	5	18	90
	Men's Field/Liner	0	0	2	10	18	90
	Arctic/Liner	0	0	2	10	18	90